MANUAL OF EXAMINATIONS

FOR

ENGINEERING POSITIONS

IN THE

SERVICE OF THE CITY OF NEW YORK

QUESTIONS AND ANSWERS

IN 3 VOLUMES AND 8 PARTS

VOL. I. AXEMAN, CHAINMAN AND RODMAN, LEVELER, TRANSITMAN AND COMPUTER
VOL. II. ASSISTANT ENGINEER.
VOL. III. DRAFTSMAN AND INSPECTOR.

TO WHICH ARE ADDED APPENDIXES GIVING

EXAMINATION PAPERS, ETC.

IN THE CIVIL SERVICE OF THE FEDERAL GOVERNMENT (INCLUDING PANAMA CANAL AND UNITED STATES NAVY), NEW YORK STATE, BOSTON, NEW ORLEANS, ETC.

BY

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PUBLISHERS' NOTE.

When announcement was made that these volumes were in preparation, inquiries and orders poured in very rapidly. In order to make the various parts available for the forthcoming examinations, the preparation of the manuscript, and the composition and presswork had to be completed with all possible haste, which accounts for the various typographical errors that have crept in, particularly in the case of Vol. II, Part 2. A sheet of errata has been prepared, and the publishers, as well as the authors, would thank the readers for calling attention to any other errors that may be discovered, which will be corrected in the next edition.

PREFACE.

"Civil Service" has had such a marked development during the past decade that it has come to be recognized as one of the important institutions in our civic life. In the Federal Service, as well as in that of many States and municipalities, thousands of positions which for years were under political control are now filled on the basis of merit and fitness as ascertained by competitive examinations.

Especially is this true in positions requiring knowledge of a technical character, and, in the City of New York alone, over two thousand persons hold civil engineering positions, the majority of which have been filled through the medium of competitive examinations. The widespread interest in these examinations has brought to editors of technical journals numerous inquiries concerning their scope, character, frequency, etc., requests for sample questions and for suitable books of reference. Considerable difficulty was experienced in answering many of these queries and in making recommendations, for, while excellent text-books were to be had, no single work was available containing the desired information.

The present book aims in a measure to fill the want that has been so long apparent.

Some difficulty was experienced in its preparation. To cover the whole field of Civil Engineering was impracticable, and another text-book would not materially aid the candidate. The authors therefore decided at the outset that the most appropriate information to include in a work of this character would be:

1st, Previous Examination Papers—giving as many sets as were readily available.

2nd, Typical Questions and Answers—such answers to be brief and to the point, and, while giving the information asked for, to avoid text-book discussion; in short, to indicate what may be expected of candidates in the examination room.

In the "Previous Examination Papers" the questions may not, in all cases, be identical in wording with those actually given at the examinations, as copies of the original papers were not readily procurable, but they embody the substance of the questions asked.

The "Typical Questions and Answers" are not intended to be perfect or complete, as reasonable variance of opinion may exist as

to what is the best answer in many cases, owing to differences in interpretation of the question and in the education and experience of the candidate. In several instances, where questions on a given topic were few in number, the answers were intentionally enlarged upon.

Examinations are not always the best tests of merit and fitness, and they are never conclusive; but they must be employed for want of better means. Incompetent men occasionally succeed while others fail, such failure usually arising from lack of preparation. or inability to put on paper the requisite information in a given time. To the latter, the authors hope this book will prove useful, and also serve as a review and guide to engineers seeking to enter government employ. It is also hoped that the extensive collection of examination papers will prove useful to Civil Service Examiners in preparing new papers, and to instructors and students in engineering schools, for the purpose of quizzes and reviews, especially now that the introduction of Civil Service in the curriculum of such schools is being advocated.

As a matter of convenience, the book has been divided into eight parts, each complete in itself, the division being based upon the classification obtaining in New York City. As similar questions occasionally appear in the examination papers for different positions, it has been deemed advisable to repeat the answers, with due regard, however, to the requirements of the position. The parts were issued separately, and not in regular sequence, to render them available for the forthcoming examinations. For this reason the paging in the volumes is not consecutive. It is intended to remedy this in future editions.

Appendixes have been added to the first and second volumes, containing the formulas which appear in the text and some of the more common formulas with which the candidate should be familiar.

For those desiring information concerning examinations outside of New York City, an extensive appendix has been added, giving the Rules and Examination Papers for the United States Navy, Panama Canal and other Federal positions, the New York State Service, Boston, Buffalo and New Orleans, etc.

The work complete contains over one hundred sets of "Previous Examination Papers," comprising over two thousand questions and answers to about a thousand typical questions. Interleaving has

been introduced for the convenient addition of new sets and to provide space for notes, sketches, etc.

It may not be amiss here to say that the Civil Service of New York offers a broad and attractive field for engineers. The many public improvements under way and projected have necessitated the employment of a large number of technical men. Most of the candidates who pass the examinations receive appointment at fair salaries, and the opportunities for promotion and advancement are quite good.

Extracts from the rules and regulations governing the service in New York City and other pertinent data appear in the introduction.

The Authors are indebted to Mr. M. Feldman of the Department of Bridges for valuable assistance in the preparation of Volume III; to Mr. G. Harwood Frost, manager publication department, *Engineering News,* for advice and suggestions; to the Keuffel & Esser Co. of New York for the loan of many cuts.

Thanks are also due to those who kindly furnished copies of examination papers.

M. H. L.
M. K.

New York, October 1, 1906.

INTRODUCTORY.

The Civil Engineer Service of the City of New York forms one of the most important arms of its municipal organization, having under its direction the prosecution of public works involving a large part of the annual expenditures. This service embraces nearly 2 500 employees, most of whom, as stated in the preface, obtained their original appointment through competitive examinations. Positions in the lowest grades are filled by original appointment of successful candidates, and those in the higher by promotion, where possible. Owing to the lack of sufficient eligibles to meet the demands of the service, many examinations have been held during the past five years for the higher grades, and most of the successful candidates have received appointment. Applications for examinations are only received at stated times and on prescribed blanks, which may be obtained by addressing the Municipal Civil Service Commission, 299 Broadway, New York. The following table gives an idea of the classification, distribution and compensation of the Civil Engineering Employees. Extracts from the rules of the Commission follow the table, giving the pertinent information relative to Appointment, Promotion, Transfer, etc.

TABLE SHOWING APPROXIMATE NUMBER OF CIVIL ENGINEERING EMPLOYEES IN THE CLASSIFIED CIVIL SERVICE OF THE CITY OF NEW YORK, JANUARY 1, 1906.

Position.	Finance, Tax and Law Departments.	Aqueduct Commission.	Board of Estimate.	Department of Bridges.	Department of Docks.	Department of Water Supply, Gas and Electricity.	Department of Parks.	Rapid Transit Commission.	Board of Water Supply.	President Borough of Manhattan.	President Borough of Bronx.	President Borough of Brooklyn.	President Borough of Queens.	President Borough of Richmond.	Board of Education.	Totals.	Compensation in most cases.	Remarks.
Assistant Engineers......	6	27	6	35	18	34	4	88	15	20	49	34	26	14	....	376	$1 200 to $3 000 per annum.	Includes about 50 Chief and Division Engineers, salary $4,000 and over.
Transitmen and Computers..................	15	8	....	10	11	12	....	....	6	6	31	18	5	7	....	129	$1 200 to $1 800	
Draftsmen— (Structural, Architectural, Topographic and Mechanical)...........	29	....	1	17	24	23	1	25	6	6	31	29	46	20	130	388	$900 to $2 700	Majority, $1 200 to $1 800.
Levelers..................	....	14	....	7	10	16	1	....	5	5	18	8	1	25	....	110	$1 200 to $1 500	
Rodmen..................	....	18	3	6	10	14	2	100	15	5	31	12	5	25	....	246	$900 to $1 200	
Axemen..................	....	35	6	6	....	14	....	50	24	9	34	6	1	20	....	205	$720 to $900	
Inspectors— (Masonry, Building, Steel, Paving, etc.)....	8	32	....	17	....	50	4	65	....	160	155	160	33	12	70	766	$4 to $7 per day $1 200 to $1 500 per annum.	Does not include Plumbing, Sanitary, Pile Driving, and Tenement House Inspectors.
Totals..............	58	134	16	98	73	163	12	328	71	211	349	267	117	123	200	2 220		

*There has since been a large increase on the staff of the Board of Water Supply.

EXTRACTS FROM THE RULES OF THE MUNICIPAL CIVIL SERVICE COMMISSION OF THE CITY OF NEW YORK.

RULE VIII—FILING OF APPLICATIONS.

1. Applications for examination for positions in the Competitive Class shall be addressed to the Commission on a prescribed form, in the handwriting of the applicant, and accompanied by such certificates or other evidences as to citizenship, character, condition of health, education, previous employment, training and fitness as the Commission may require.

The statements of the applicant in these particulars shall be made under oath, properly attested.

2. Every application shall bear the certificate of four reputable citizens, whose residences or places of business are within the City of New York, to the effect that they have personally known the applicant for not less than one year, that they have read his statements and believe them to be correct, and that they will, upon request, give such further facts concerning him as they may possess, either for the files of the Commission or for the information of appointing officers.

If the previous occupation or employment of the applicant has been wholly or in part outside the City of New York, not more than two of the said certificates may be accepted, in the discretion of the Commission, from persons resident or engaged in business elsewhere; but no such certificate shall be accepted from a near relative of the applicant, or from any person the character of whose business, in the judgment of the Commission, may disqualify him as a fit voucher.

3. The Commission shall, by regulation or otherwise, fix the limits of time between which applications for a given examination shall be presented; but such period shall in no case be less than two weeks, and there shall be not less than five days between the last date for the presentation of applications and the date of examination.

4. An application presented within the prescribed limits of time, but found to be defective, shall be suspended, and notification shall be given to the applicant of the particulars in which it requires correction. Such an application shall be accepted if corrected and returned before the date of examination, but not otherwise.

5. Applications when presented shall be dated, numbered, and recorded in the order of their receipt. An application that has been accepted and filed shall not be returned for any reason to the applicant.

6. A person claiming rights of preference as a veteran shall file, with his application, proof of such veteranship and of his residence within the State of New York.

7. Application forms shall be furnished to intending applicants, upon personal or written request, at the office of the Commission, and shall be procurable there only.

RULE IX—MARKING AND RATING.

1. The examination papers shall be rated, in each case, by at least two examiners assigned therefor, who shall review them separately, and after such rating is completed shall affix to each a mark expressing the average of their judgment, attested by their respective signatures or initials. The marking shall be strictly comparative and according to such standards of proficiency as the needs of the service may require. Each subject shall be marked upon a scale of 100, which shall represent the maximum possible attainment.

2. Every candidate who receives a general average marking of not less than 70 per cent., and who has received not less than 20 per cent. in any required subject, or not less than 75 per cent. in any technical subject, when the examination is for a position of scientific, professional or technical nature, shall be eligible for certification and appointment in the manner, and under the conditions, hereinafter prescribed.

3. Where the Chief Examiner is satisfied, through investigation made under his direction, or otherwise, that the general character or the reputation of a candidate whose papers have been marked is not good, the name of such candidate shall not be placed on any eligible list; but all action under this clause shall be reported in writing, with the reasons therefor, to the Commission and shall be subject to the Commission's approval. The burden of proof of good character shall be upon the candidate who may, where doubt exists, be required to furnish evidence thereof additional to the certificates required at the time of his application.

4. The Secretary shall, as early as practicable after the completion of an examination, notify each candidate of the rating he has received, and of his relative standing, if such rating be above the minimum. He shall in the same manner notify any candidate who may be rejected for reasons other than failure to receive the minimum average, stating such reasons specifically.

5. A candidate receiving such notice may personally inspect his examination papers, in the presence of a designated officer or employee of the Commission, and, if he believes that any error or mistake in marking appears, or that injustice has otherwise been done him, may, not later than fifteen days after the date of such notice, file an appeal with the Commission, specifying particularly

the grounds of his complaint. The Commission shall take such action with reference to such appeal as substantial justice may require.

RULE X—ELIGIBLE LISTS.

1. The results of each examination shall be reported by the Chief Examiner to the Secretary, who shall enter the names of the persons passing, in the order of their average rating, on the proper list of eligibles; provided that the names of veterans so passing shall be entered, in the order of average rating, at the head of such list. The date of the establishment of a list shall be the date of such report.

2. When two or more eligibles on a list have the same average rating, preference in certification shall be determined by the order in which their applications were filed, or, if the examination be for promotion, by the order of their original appointment in the department or other division of the service in which the promotion occurs.

3. The term of an eligible list shall be not less than one year nor more than four years from the date of its establishment. An eligible list that has been in force for one year, except for the position of temporary clerk, shall terminate whenever a new list is established under the same title, and, in case of a graded position, for the same grade or grades.

Persons whose names appear on a list about to be terminated shall be notified of the new examination, in the same manner that applicants therefor are notified, and shall be informed that, upon the establishment of the new list, their original eligibility shall cease.

4. All eligible lists shall be published as early as may be practicable after their establishment, in the "City Record."

RULE XI—CERTIFICATION AND APPOINTMENT.

1. Selections for appointment to all positions in the Competitive Class not filled by promotion, reduction, transfer or reinstatement shall, except as provided in Rule XII, be made in the following manner:

The appointing officer shall notify the Commission of the title of the position, the duties to be performed and the compensation to be paid. The Commission shall thereupon certify to such appointing officer from the eligible list most nearly appropriate to such position, and for the grade thereof, if in a graded service, the three names at the head thereof; provided that, except in the case of a veteran, no such name shall be certified more than three times to the same appointing officer for the same or a similar position, unless at such officer's request. The relative rating of each candidate shall be stated in the certification, and, if the appointing officer requests, the application and examination papers of each shall be

submitted for his inspection, at the office of the Commission. Certification shall be made without regard to sex unless sex is specified in the requisition.

The appointing officer shall make selection, with reference solely to merit and fitness, from the three names certified, unless objection shall be made, and sustained by the Commission, to one or more of the persons named, in which case the certification of three names shall be completed by addition of the name or names next following upon the eligible list. If there be more than one vacancy to be filled, names shall be certified and selection shall be made for each of such vacancies in the same manner.

2. The person selected shall be duly notified by the appointing officer, and, upon accepting and reporting for duty, shall receive from such officer a certificate of appointment for a probationary period of three months; except in the Police or the Fire Service, where such period shall be one month. If his conduct or capacity on probation be unsatisfactory to the appointing officer the probationer shall be notified in writing that at the end of such period he shall, for that reason, not be retained; his retention in the service otherwise shall be equivalent to permanent appointment.

3. A probationer separated from the service for any reason other than fault or delinquency shall be restored to the eligible list from which he was selected, with the same relative standing, and the time during which he has actually served shall be deducted from the period of probation if he be again selected by the same appointing officer. When two or more persons selected from the same eligible list are serving as probationers under the same appointing officer, and a reduction of force is necessary, they shall be preferred for retention in the order of their original standing on such list.

4. The name of any person certified as eligible for a probationary appointment who shall decline such appointment shall be stricken from the list from which such certification is made, unless such declination be for one of the following reasons:

(*a*) Residence in a borough other than that in which the duties are to be performed; (*b*) insufficiency of the compensation offered, if such compensation be lower than the amount or the maximum amount stated in the announcement of examination; or (*c*) temporary inability, physical or otherwise, the evidences of which must be acceptable to and approved by the Commission and set forth in its minutes.

The failure of an eligible person to respond within four days to an offer of appointment sent to his post-office address shall be considered a declination.

An eligible who has declined appointment by reason of the insufficiency of the compensation offered shall not be again certified for a position at the same or any less compensation, and whenever

one or more eligibles shall have declined appointment to any position for such reason, and an eligible whose standing is lower is appointed thereto, the compensation of such appointee shall not be increased within one year thereafter beyond the amount offered to any person so declining.

On notification from an appointing officer that a person named in a certification has declined appointment, and on receipt from such officer of such declination in writing, or of evidence of the failure of such person to respond to a notice properly sent, such certification shall be completed by addition of the name of the eligible next in order.

5. No certification shall remain in force for a longer period than fifteen days. Until such certification has been exhausted or terminated no new certification shall be made for the same position, but the names of the persons certified may be certified for any similar position.

6. Every person selected for appointment shall be required to fill out and sign, in the presence of the appointing officer or his representative, an identification sheet, repeating the essential facts stated by him at the time of examination, which shall be forwarded to the Commission with the notice of appointment and filed with the appointee's application papers.

If a person who is not entitled to certification is certified and appointed, his appointment, upon due notification from the Commission to the appointing officer, shall be revoked.

RULE XIII—SUSPENSION AND REINSTATEMENT.

1. Whenever any permanent position in the Competitive Class is abolished or made unnecessary, or whenever the number of positions of a certain character is reduced, the person or persons legally holding such positions shall be deemed to be suspended without pay, and the names of such persons shall, on due notification from the appointing officer, be placed by the Commission on a special list, under such classified title and corresponding to such competitive eligible list as, in the judgment of the Commission, most nearly cover the class of duties performed by such persons in the position from which suspension is made. For a period of one year from the date of suspension such persons shall be entitled to reinstatement in any position, or any grade of such position, for which certification from such corresponding eligible list might be made, and the Secretary shall certify their names to the proper appointing officer as entitled to such reinstatement, in the order of the dates of their original appointment to the Classified Service, before certification is made from such corresponding eligible list for any such vacancy; provided that such persons shall be selected for certification, *first,*

for a position the same as that from which suspension was made, if the vacancy exists in such a position, and *second,* for corresponding or similar positions.

A person so certified who declines to accept a reinstatement, except for one of the reasons and under the conditions stated in subdivision 4 of Rule XI, shall be considered to be permanently separated from the service.

2. The provisions of the foregoing clause shall not apply to any person who resigns his position or who is suspended or removed therefrom for any reason other than those therein specified. Leaves of absence without pay may be granted by an appointing officer, without conflict with such provisions, where such absence does not exceed thirty days, or in case of sickness six months; but the Commission, in exceptional cases, the circumstances of which shall be stated in its minutes and in its annual report, may extend such periods. Absence without leave for a period of five days, unless it be subsequently shown that such absence was unavoidable, shall be construed as a resignation.

3. A person who has resigned from a permanent competitive position, or who has been removed or otherwise separated therefrom from any cause other than fault or delinquency on his part, may be reinstated without examination, at any time within one year from the date of such separation, in a vacant position in the same class and grade, provided that for original entrance to such position there is not required by these rules, in the judgment of the Commission, an examination involving tests or qualifications different from or higher than those involved in the examination for appointment to the position formerly held by such person. But no person shall be so reinstated who at any time within a year prior to the date of his separation from the service had been eligible for reinstatement as a suspended employee.

The Commission may in its discretion extend the period during which reinstatement may be made under this clause where the person seeking reinstatement resigned his position in order to serve in the Army or Navy of the United States in time of war, and has received an honorable discharge therefrom.

RULE XIV—TRANSFER.

1. A person who has been permanently appointed to a position in the Competitive Class may be transferred without examination to a similar position in such class, or to a position of the same grade thereof, if it be in a graded service, in any other department, office or institution; provided that for original entrance to the position proposed to be filled by transfer there is not required by these rules, in the judgment of the Commission, an examination involving tests or qualifications essentially different from or higher than those

required in an examination for original entrance to the position from which transfer is sought; or provided he shall have passed the examination or obtained a place upon the eligible list in force for such position; and provided further that if such person entered the service without competitive examination, and prior to the requirement thereof in the case of the position held by him, he shall have served with fidelity for at least three years in such position, or in a similar position.

2. A person may be transferred from a position in one class to a position in another class, or from a position in any grade of the Competitive Class to a different grade in such class, who has served a year in the position from which transfer is sought, under special authority granted by the Commission, for reasons to be stated in its annual report, and subject to the provisions of Clause 1 of this rule.

3. A person who, by transfer or promotion from a competitive position, is holding a position in another class or in another grade, and who has served continuously therein from the date of such transfer or promotion, may be retransferred, without the application of the foregoing restrictions, either to the position originally held by him, or to any position to which transfer could be made therefrom.

4. Upon the written request of an appointing officer, stating the facts with reference to a proposed transfer, accompanied by the consent, also in writing, of the appointing officer from whose jurisdiction the transfer is to be made, the Commission will, if such transfer be in accordance with law and the provisions of these rules, issue its certificate to that effect; but no such transfer shall be made or recognized until after the issuance of such certificate.

RULE XV—PROMOTION.

1. Vacancies in positions above the lowest grade in any Part of the Competitive Class, except Part I, that are not filled by original appointment, transfer, reinstatement or reduction, shall be filled by promotion, based, so far as practicable, on competitive tests.

2. Examinations for promotion shall be ordered as often as may be necessary to meet or to anticipate the needs of the higher grades, and, so far as practicable, shall be held periodically. Except where otherwise provided by law, such examinations shall be open, in each case, to all persons who shall have served with fidelity for not less than six months in positions of the same group or general character in the grade next lower, in the same department, office or institution; except that, for reasons to be set forth in its minutes, and where permitted by law, the Commission may open such examination to persons in two or more lower grades who shall have served

with fidelity for not less than six months in the periods held by them respectively.

Notice of such examination shall be given by the Secretary to all eligible persons in the grade or grades from which promotion is to be made at least one week in advance of the date thereof.

3. A position in any of the aforesaid Parts the compensation of which is not identical with that specified in the Classification for any grade of such Part shall, for purposes of promotion, be deemed as of the grade the compensation of which is specified as next lower than the compensation paid.

6. The subjects of rating and the relative weights thereof, in any competitive promotion examination, shall be as follows: For seniority of service in the position or grade from which promotion is sought, 20; for comparative conduct and efficiency in previous service in such position or grade, 40; and for written papers on pertinent subjects, 40; provided, that in rating for seniority, where more than one grade is opened, such rating shall be based upon the service of a candidate in all of such grades; and provided further that the maximum term of service in a position or grade to be considered in rating for seniority shall be fifteen years.

RULE XVI—REMOVALS.

1. No person holding a position in the service of the city shall be removed from such position, except in the manner prescribed by the Charter and the Civil Service Law; and the officer charged with the power of removal, in each case, shall transmit to the Commission, with the report of his action required under Rule XX, a copy of the reasons therefor, or of the findings of any trial board or officer, as stated to the person removed, and as filed in the department or office.

2. No person who is an honorably discharged soldier, sailor or marine, having served as such in the Union Army or Navy during the War of the Rebellion, or in the volunteer army or navy of the United States during the Spanish War, or who is a veteran volunteer firemen, shall be removed from any position in the Classified Service except in the manner prescribed by section 21 of the Civil Service Law.

3. The provisions of this rule shall apply to the removal of any person from a graded position by reduction to a position in a lower grade, but shall not apply to a suspension from service for lack of work or reduction of force.

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VOL. I. PART I.

AXEMAN.

INDEX.

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PREFACE.

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In the section devoted to "Typical Questions and Answers," the answers indicate in a general way only what is required of the candidate, and are not intended to be perfect and complete, as reasonable variance of opinion may exist as to what is the best answer in many cases, owing to differences in interpretation of the question and in education and experience.

In order to perpetuate the value of this book, blank leaves have been inserted after the "Previous Examination Papers," allowing for the convenient addition of new sets, and the "Typical Questions and Answers" have been interleaved, to provide space for notes, sketches and additions.

PREVIOUS EXAMINATION PAPERS.

AXEMAN.

TECHNICAL.

(*Salary—$720 per annum.*) 1901.

1. Describe the shaping and driving of a stake so as to secure the best result as to solidity and accuracy of position.

2. What does a rodman have to do besides carry and drive stakes?

3. What conditions control the sizes and lengths of stakes?

4. How would stakes be set for a job of sewer work?

5. In doing street grading, where slopes have to be provided for, state the positions of all stakes that would be set at a cross-section in embankment, and also what marks would be placed on them.

6. (*a*) Describe fully the work of setting a centre stake on a transit line. (*b*) How are such stakes marked?

7. Describe the operation of cutting a good bench mark on the root of a tree.

8. In what other ways besides the use of stakes are stations marked on a line?

9. In doing leveling, where points have to be set on between stations, what are such points called?

10. Describe the operation of setting reference stakes or otherwise referencing a point which may be lost unless so marked.

11. Describe the method you would pursue to cut straight on a line through brush.

12. (*a*) If called upon to set up a transit instrument, what two points are to be particularly attended to? (b) Would you screw the leveling screws very tight, or how?

13. Write decimally the following number: One million, twenty-three thousand and eighty and thirty thousandths.

ARITHMETIC.

1. Add 219 ft. 7 in., 847 ft. 9 in., 796 ft. 3 in., 654 ft. 11 in., 798 ft. 5 in.

2. Multiply 690,875 by 78,096.

3. Add 2-3, 5-8, 4-9, 11-16, 17-18.

4. If $9\frac{3}{8}$ yards of cloth cost $\$26\frac{1}{4}$, how many yards could be bought for $\$24\frac{4}{5}$?

5. If $3\frac{3}{4}$ is $2\frac{1}{2}$ times a certain number, what is $3\frac{1}{8}$ times the same number?

6. Divide 322,622,362 by 78,746.

AXEMAN.

Technical.

1902.

1. May a stake drive crooked from improper driving? If so, state in what way?

2. What other causes may make a stake drive badly?

3. (*a*) How far apart are centre stakes ordinarily placed on the line of a street to be graded? (*b*) How far apart are stations made on sewer work?

4. (*a*) What marks are placed on centre line stakes for grading a street? (*b*) Are stakes ever placed between regular stations, and if so, how are they marked?

5. (*a*) In what way can an axeman assist the chainman in windy weather? (*b*) How can he assist the transitman in such weather?

6. (*a*) How are stations marked on rocks? (*b*) How on a stone-block pavement? (*c*) How on an asphalt pavement?

7. If called upon to hold the front end of a chain, state all the things you must attend to, in order to get correct measurements.

8. Show and describe how you would cut a bench mark on the root of a tree.

9. If called upon to hold the rod, state all you would do in a case where the rod had to be extended.

10. Describe the operations of setting up a transit instrument in the field, not using the box.

11. What other duties ordinarily fall upon an axeman besides those mentioned in previous questions?

12. Write the following number (not numbers) decimally, ten thousand and seven and forty-three ten thousands.

Arithmetic.

1. Addition.

2. Multiplication.

3. Add 3-5, 5-8, 11-16, 7-15, 3-10.

4. What number added to 7-9 of 18 3-4 will equal 9-10 of 41 2-3?

5. If a laborer can reap a field of grain in 4 4-5 days, how long would it take four laborers to reap a field 6 1-4 times as large.

6. Division.

AXEMAN.

TECHNICAL.

1903.

1. What are the duties of an axeman as you understand them?

2. In carrying an instrument on the tripod, where there are bushes and fences, what is the safest way?

3. If called upon to set up a transit instrument over a point, state the important things you should pay attention to?

4. In what ways can an axeman assist a transitman while he is setting up a transit?

5. How do you fix points in soft, marshy ground?

6. If for any reason you were told to set an offset stake at the end of a line, how would you do it?

7. (*a*) What do the letters T. P. mean when used in connection with a set of levels? (*b*) What do the same letters mean when used in an extensive survey of a portion of the city?

8. In the transit work (not the level work) of running the centre line of a street in the city, how far apart are the stakes usually placed and what marks are placed upon them?

9. What additional marks are placed upon them to indicate what grading is to be done?

10. When heavy filling or cutting are to be done, what other stakes are set at each station besides the centre stakes and how are they marked?

11. Write in figures, the whole number, one million seventy thousand and five hundred and seven, followed by a decimal number fourteen thousandths?

12. Write in words the following number, 3099077009.

MATHEMATICS.

1. Addition.

2. Find the amount of

$$\frac{19\ 4\text{–}5}{16\ 7\text{–}3} + \frac{20\ 5\text{–}9}{54\ 3\text{–}7}$$

3. A field is 56 rods wide and contains 25 acres 88 square rods. Find the cost of fencing it at $66\frac{2}{3}$ cents a yard.

4. If a man can walk 200 miles in 9.375 days, how far, at the same rate, can he walk in 15.625 days?

5. A church is 85.64 ft. long, 51.28 ft. wide and 31.5 ft. high to the eaves. Find the cost of painting the outside walls at 34 cents a square yard.

EXPERIENCE.

1. What is your age?

2. (*a*) State what your education has been, giving dates and places. (*b*) State particularly whether you have pursued any engineering studies, and if so, state the length and character of the course.

3. State fully the practical experience you have had with engineers, giving length and character of service.

4. Give the names and addresses of two or more persons to whom application may be made, if necessary, for verification of your statements.

AXEMAN.

Technical.

November 3, 1905.

1. (*a*) Write in words 1006.306. (*b*) Write in figures seventy and three hundredths.

2. What is the difference in area between 4 square feet and four feet square?

3. How many tenths of a foot are there in 30 inches?

4. What is the difference between a rod used for a transit survey and one used for a level survey?

5. In cutting brush, what is the best way to keep on line?

6. Assume that the engineer sent you to the office to bring everything necessary for a transit survey; what would you bring?

7. How is a stake referenced when it is likely to be destroyed?

8. How many stakes would be required to give stations in a transit line half a mile long, allowing 7 for plus stations, including the last stake?

9. Where a railroad cut is to be made, where are the stakes set?

10 and 11. Write in plain letters (about $\frac{1}{2}$ in. high) the abbreviations for the following as written on stakes: (*a*) Forty-one plus fifty, center Line; (*b*) Slope Stake 15 numerator, 20 denominator; (*c*) Bench Mark, plus seventy-one, point, two, six, three.

12. (*a*) How is a transit point accurately marked on a stake; (*b*) How when it falls on a rock ledge?

13. In going through brush with an engineer's instrument on its tripod, what is the safest way to carry it?

14. How would you clean a rusty tape?

15. How would you set up an engineer's instrument?

Mathematics.

Give all the figuring on the ruled sheets.

1. Add 49 ft. and 8 in.; 6 ft. and 9 in.; 13 ft. and 11 in.; and 7 ft. and 8 in.

2. Add 4.05 ft., 19.982 ft., 17.33 ft. and 2.638 ft.

3. Subtract by fractions and by decimals $\frac{3}{8}$ from $\frac{12}{16}$.

4. Divide $2\frac{1}{2}$ by $\frac{4}{5}$, multiply by $\frac{3}{8}$, add $\frac{3}{4}$ and subtract $\frac{1}{2}$. What is the result?

5. Four men working 8 hours each can shovel 128 cu. yd. of earth; how many cubic yards of earth can 8 men shovel if they work 12 hours each at the same rate?

MANUAL OF EXAMINATIONS

FOR

ENGINEERING POSITIONS

IN THE

SERVICE OF THE CITY OF NEW YORK.

AXEMAN.

TYPICAL QUESTIONS AND ANSWERS.

AXEMAN.

TYPICAL QUESTIONS AND ANSWERS.

1. What are the duties of an axeman?

The duties of an axeman are to prepare, drive and mark stakes; to cut brush, fell and blaze trees, and keep the line clear for sighting and chaining as directed. He must cut points on stones, assist in setting up instruments, in chaining and running the rod. He must carry tools, keep them in good condition, and be generally useful.

2. What tools would you be likely to handle in a transit party, and for what purposes would you use them?

A broad axe for felling and blazing trees and for driving stakes.

A hatchet for driving spikes, trimming stakes, cutting benches, etc.

A brush hook for clearing lines.

A hammer, chisel and punch for cutting marks on stones.

A bar or pick, shovel and trowel for uncovering transit points, digging up hard or frozen ground, etc.

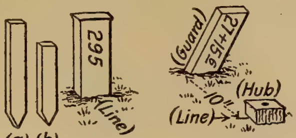
3. What are stakes used for?

Stakes are used to mark points required for future use, for example, to fix transit points, to mark lines, grades, stations, slopes, etc., and to reference important points.

4. Describe the various kinds of stakes that are best adapted for the purposes mentioned in Question 3?

For transit points, stakes should be of oak, locust or chestnut, about 2 to 4 in. square, or 2 to 4 in. in diameter, if round, and about 15 to 18 in. long, sharpened at one end for driving.

For grades, stations, slopes, references and finders, stakes should be of pine or other available timber, about 1 in. thick, 2 to 4 in. wide and 15 to 20 in. long, squared and trimmed on one or both sides for marking, and sharpened on one end for driving.



(a) (b) Station Stake. Hub with Guard Stake.

5. How should stakes be pointed?

They should be pointed evenly on all sides to make them drive straight.

6. How should stakes be driven?

Stakes should be driven straight down. If the stake tends to slip by the point, it should be drawn and not straightened after driven. It should be firm and at the required depth. If the stake is driven slightly off line it may be brought to its proper position by driving a stone or another stake against it.

7. What causes may there be for a stake not driving straight?

It may not be properly pointed, not started straight or not struck squarely on top. It may strike a stone or some other obstacle in the ground.

8. After a stake has been driven in soft ground and is still loose, what do you think it advisable to do?

Draw the stake and substitute a longer one, or if no longer one is at hand, try the same one again after filling the hole with solid material. If this fails, the stake may be made firm by wedging it between other stakes previously driven around the point.

9. How are stakes marked?

Line stakes are marked by their stations, viz.: full stations 0 + 00, 5 + 00, etc., intermediate points being marked with the plus

from the last full station, as 0 + 50, 5 + 65, etc. They are marked so one can read the stations in walking forward along the line.

On grade stakes the cut or fill is marked thus: C. 5.4, F. 2.3, etc. The distance to the right or left of the centre line may be marked on the other side.

Slope stakes are marked with the word "slope," "s. s.," "slope left," etc., and the distance from the centre may be put on the other side.

Reference stakes are marked with the letters "R. P.," the station of the point referenced, and the distance to it. The marking should face the point referenced.

10. What is meant by a reference stake and what references are given to it?

A reference stake is a finder for some important point of the survey. Two or more such stakes will enable one to locate the point referenced, although all trace of it is lost. The description of the reference stakes, the distance and the general direction to the point reference are given.

11. What is a finder stake?

A finder is usually a flat stake set alongside another which is flush with the ground, to help find the latter. The finder is left a foot or so above ground, the marking facing the original stake.

12. For what purpose are stakes set between regular stations?

Stakes are set between regular stations where there is a change of grade, where the line changes its direction, or at the beginning or end of a curve; also at prominent breaks in the slope of the ground, and at points where the grade runs out.

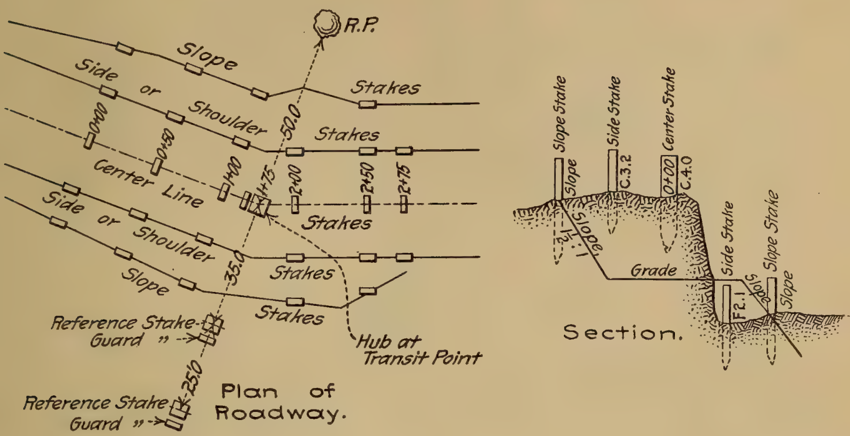
13. When a street is to be graded through fields and a deep cut is to be made, state how far apart the regular stations would be and just what stakes the engineer would set at each station.

The regular stations should be 50 ft. apart on tangents and 25 ft. apart on curves. Where rock is encountered the stations should be about 25 ft. apart. At each station the engineer would set:

A centre stake with the station and the centre cut marked upon it.

A grade stake at each side line with the cut marked on it.

A slope stake at the intersection of each slope with the natural surface of the ground.



14. How would you locate an important stake in high grass?

An important stake in high grass or in places where it may be lost or not readily found should always be referenced to trees or other permanent objects, or else to other stakes driven some distance away. A long finder having a small flag attached should be driven beside the stake.

15. Where and how are reference points fixed?

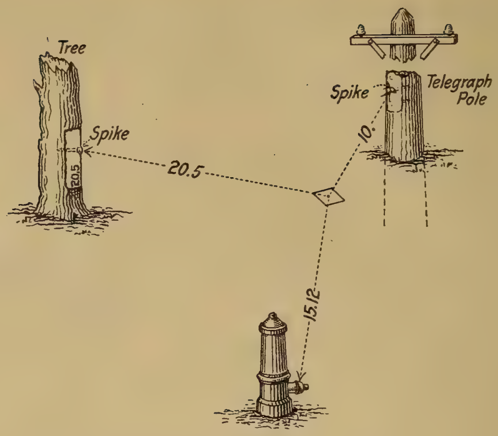
They are usually fixed in places that are likely to be permanent, such as corners of buildings, monuments, fire hydrants, catch basins, telegraph poles, trees, etc. The distances from two or more of these reference points to the points to be referenced and their description are recorded for future use.

16. Suppose a point that has been referenced is lost, how can you relocate it?

By swinging arcs from the reference points as centres and with the recorded distances as radii. The point of intersection of these arcs will be the point sought.

17. What kinds of objects make good reference points?

Objects which can be readily found and which are not likely to be removed for a considerable period, such as corners of houses, lamp posts, hydrants, poles, trees, etc.



18. How would you mark a point on a stake?

A point on a stake is marked by a tack, preferably of brass.

19. What are the stakes at the beginning and the end of a curve in a street or railroad called?

At the beginning of a curve they are called points of curve (P. C.) and at the end of the curve points of tangent (P. T.).

20. In running lines how are offset stakes set and what are they used for?

They are set at right angles to the line run, and generally at a whole number of feet from it. They are necessary when an obstacle is on line (as a house, barn or tree) to continue the line beyond the obstruction. They may also be used as references in case the point on line is dug up or destroyed during construction.

21. How can you locate a point in a bog?

By driving a long stake and wedging it, if necessary, or by referencing the point and relocating it from the references whenever the point is to be used.

22. How would you fix a point where for any reason stakes cannot be driven?

If on a stone or flagging cut a cross, crowfoot or triangle, etc. On macadam or asphalt, drive a spike. In any case reference the points.

23. How can a point be fixed on solid rock?

A cross or other suitable mark may be cut in the rock, or a copper plug set in sulphur or cement may be inserted in a hole drilled in the rock and the point marked on the plug.

24. How would you fix a point in macadam?

By means of a spike, or by driving a stake into a hole in the macadam, previously made with a bar.

25. Suppose a transit point had to be fixed in a paved street, how can it be done?

If the street is paved with asphalt drive a nail, or remove a portion of the asphalt and drive a stake and recover. If paved with blocks, cut a mark on a block. On flagstones cut a mark, such as a cross, crowfoot, etc., as shown below. The points should be referenced.

26. What is a Gunter chain?

The Gunter or surveyor's chain is a link chain used for land surveying; it is not accurate enough for city work. It is 66 ft. long and consists of 100 links, each 7.92 in. in length. A tag is attached to each 10 ft., marked according to its position from the end.

27. What is the engineer's chain?

The engineer's chain is similar to the Gunter chain. It is 100 ft. long and contains 100 links each 1 ft. in length. A tag marks each 10 ft. of the length.

28. Why is the chain not accurate?

Because it has too many wearing surfaces which render it liable to change in length. It cannot be read closely. It is heavy and cannot be pulled taut, to overcome sag.

29. Name the measuring instruments you know of?

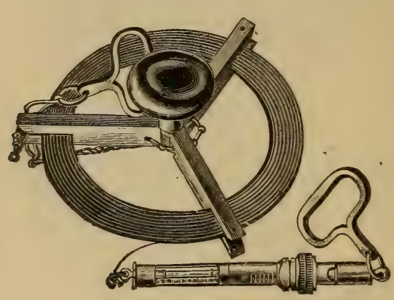
Tapes from 5 to 500 ft. in length, chains, rods, transits, levels, etc.

30. What would you consider best for distances of 10 ft. or less?

A graduated steel tape.

31. What for distances over 10 ft.?

Graduated steel tapes, and for distances over 50 ft. tapes with compensating spring balance and thermometer attachment.



32. Explain fully what must be observed in chaining?

The chain should be held horizontally; there should be no kinks nor interference. The bobs should be held steadily and accurately over the points, and the tape pulled taut. Care must be observed in keeping tally.

33. How can you tell when the tape is horizontal?

Either by a spirit level attached to the tape or by observing whether the angle made by the tape and plumb bob string is a right angle. Experience will enable one to judge very closely.

34. If you are carrying the forward end of the tape, state all the points to be observed to do accurate work.

The head chainman should observe that the tape is free from kinks and interferences, that it is horizontal, that the proper pull is applied, and that the tape and bob are held steadily and on line before the measurement is taken. After fixing the forward point, the measurement should be repeated as a check on the work. He should also call and check the stationing. If partial chain lengths are used, he should observe the reading carefully, and be sure that the rear chainman holds at the proper point at the next measurement.

35. Which is most accurate, chaining up or down hill, and why?

Down hill is the more accurate because the rear end of the tape can be held on or close to the rear point. This makes it easy for the rear chainman to hold his end, thus enabling the head man to set the forward point more accurately.

36. In windy weather is there anything an axeman can do to aid in the work, aside from driving stakes? If so, what?

He can shield the bob for the transitman while "setting up," or the bob for the chainman while chaining. He can aid in shielding the tape from the wind if accurate work is desired.

37. What is meant by breaking chain?

Where the ground is steep, complete chain lengths cannot be obtained in one measurement, and partial chain lengths must be used. This measuring in partial chain lengths is called "breaking chain."

38. In chaining down steep slopes, how would you avoid possible error in carrying the distances along?

The tape is run out its full length. The rear chainman holds zero of tape over rear point; the front chainman calls out the partial distance measured and marks the point on the tape with chalk. In getting the next measurement the rear chainman holds at the marked point, and the front chainman fixes the forward point as before. This operation is repeated until the entire chain length

has been covered, when the chain is taken ahead and rear chainman holds again at the zero.

39. If in comparing a chain you find it short, how would this affect the work done with it in this condition?

All the distances measured appear longer than they actually are, and correction should be minus.

40. If a chain be out of level in measuring will it measure too long or too short?

It will measure too long.

41. In measuring to set a point do you take the nearest or farthest point? Why?

The farthest point, because in measuring to set a point with a given tape reading, the point set is farthest when the tape is horizontal.

42. If the city buys a lot and an old Gunter chain which has not been tested is used to survey the ground, would the city pay more or less?

The city would pay less.

43. If two competent chainmen chain over a mile twice, how close should the results come?

With a link chain the results should be within 5 ft.
With an ordinary steel tape, they should be within ½ ft.
With a spring balance tape and compensating attachment, within 0.1 ft.

44. When only a part of the chain is held, which of the two chainmen takes the forward end?

The head chainman. He should always hold the forward end of the chain and thus avoid subtractions and liability to error.

45. Why do you not lay the chain on the ground while chaining?

Because the ground is uneven and offers obstructions to chaining, and secondly, because it is not usually level.

46. Why are measurements taken horizontally?

Because the map or plan of a survey is the horizontal projection of the points in the survey, and horizontal measurements give the projected distances for plotting.

47. What would you do if stakes ran short?

Obtain suitable sticks of timber or branches of trees from which stakes may be prepared.

48. What are the duties of a flagman in a transit party?

He sets the flag ahead to enable the axeman to get the line in clearing; he selects points ahead as directed by the transitman, and gives back and fore sights whenever required. The flagman should remain at a point on which a sight is being taken until called off.

49. Describe the method you would use in cutting a straight line through brush?

I would get the line from the transitman and start cutting the brush low, throwing it to one side, taking care that it does not fall across the line. I would keep in line by sighting on points which I know to be on line or by getting the line from the transitman. Where possible, the axeman should work towards the transitman in clearing.

50. How would you line yourself in, in running a transit line through a thicket?

I would place one or two rods on line high enough to see over the thicket and range myself in with these rods and the transit, if visible.

51. What is a ranging rod and what is it used for?

It is a rod of steel or wood, round or hexagonal, 6 to 10 ft. long, and having each foot painted alternately red and white or black and white, etc. The rod is pointed at the bottom, the wooden rod having an iron shoe. It is used for giving sights and ranging in lines.

52. Describe fully the work of setting a stake on a transit line. How are such stakes marked?

The transitman gives line; the rear chainman plumbs the zero end of the chain over the rear point, and the front chainman plumbs the required point on the tape. When the transitman and rear chainman both signal o. k., the front chainman sets the point on the ground. The axeman then drives a stake at this point. The chaining is then repeated and the point is now obtained on the stake at the required distance and on line. The tack is driven in

the stake at this point and the line and distance of this tack is checked.

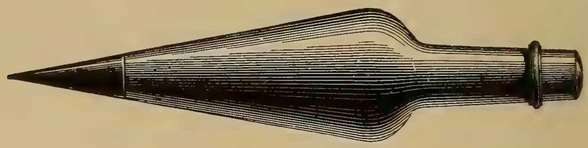
These stakes are marked with the number of the station from the beginning of the line, a whole station being 100 ft. If not at a full station, the plus distance from the preceding full station is also marked upon it.

53. How far apart should stakes be set on a job of sewer work?

In flat grades, points are given 20 ft. apart. On steep grades, 40 to 50 ft. On curves, less than 20 ft., depending upon the radius.

54. What is a plumb bob and what is it used for?

A plumb bob is a conical-shaped metallic weight suspended by a string attached to its upper end. When freely suspended, the point of the bob is vertically beneath the point of suspension. It is used in chaining, setting up the transit and by masons to get a plumb line.



55. How does a plumb bob affect the accuracy of work?

A plumb bob must be sharp and truly shaped, otherwise it will not give an accurate plumb line, thereby causing errors in setting up the transit and in chaining. It should be heavy to keep it steady in windy weather.

56. How does holding the bob affect the work?

Improperly holding the bob in chaining and giving sights causes error in the work. Lines, distances and angles are all liable to be in error. The string and bob must both swing freely, and be held steadily and accurately over the point.

57. Is there any better way of steadying a long bob string than by simply bracing yourself?

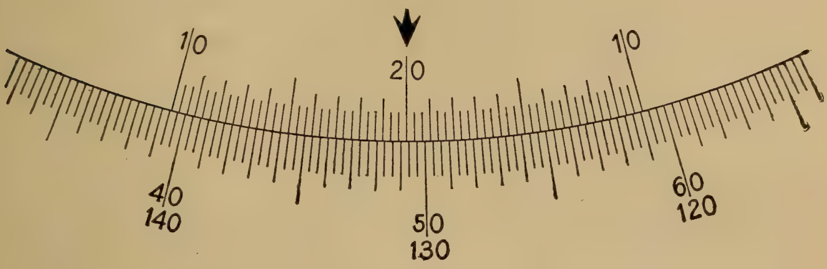
A long iron rod with a movable arm rest may be used in cases where the bob string has to be held high over the point.

58. What is a vernier?

A vernier is an auxiliary scale sliding alongside a main scale, enabling the smallest divisions of the main scale to be still further subdivided.

59. Where is a vernier used?

It is used on leveling rods, transits and other measuring instruments where very accurate readings are desired.



60. What is a leveling rod?

It is a graduated wooden rod upon which readings are taken with the level. It may be made in one piece or in two sections sliding against each other and provided with a target and attached vernier. It is graduated to feet and tenths or feet and hundredths, the vernier in the latter case reading to thousandths.

61. If called upon to hold the rod in leveling, state as far as you can all you must do to insure correct work?

Hold the rod *vertically* on the proper point.

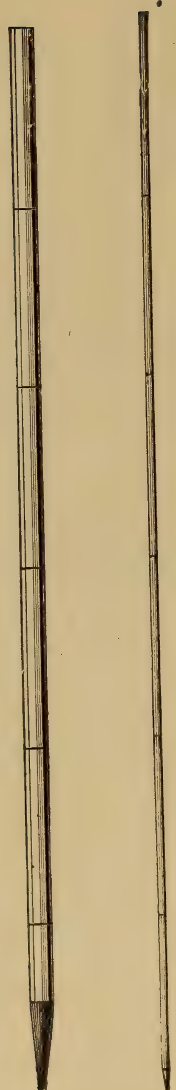
Move the target as directed by the observer.

Upon signal clamp target and hold rod for a second reading; read carefully and record. The leveler then checks the reading. If a long rod is used, care should be taken to have the target properly set.

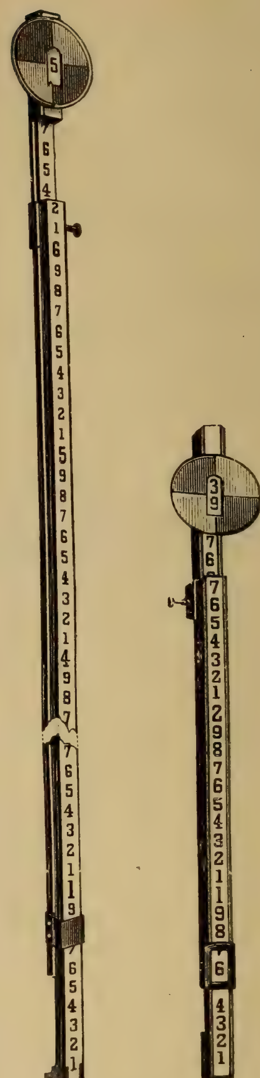
Care should also be observed that the target and rod do not slip and that the rod is held on same point in both fore and back sights.

62. Suppose that in leveling the rodman should ask you to fix a turning point (T. P.) for him, how would you do it?

Select a fixed point, visible from the instrument, at about the right height, and upon which the rod can be held vertically and freely rotated, or, if not available, a long pin or spike may be firmly driven in ground.



Ranging Rods.



Leveling Rods.

63. What is meant by a "T. P." in leveling? What in transit work?

In leveling a "T. P." is a turning point, that is, it is a point used between "set-ups" of the instrument to carry along a line of levels.

In transit work, a "T. P." is used to indicate a "Transit Point" or a point which is occupied by the transit.

64. What is a "B. M."?

A "B. M." is a permanent point whose elevation is accurately established. It is used for starting or checking a line of levels.

65. What is the difference between a back sight and a fore sight in leveling?

A back sight is a rod reading taken on a point whose elevation is known. If added to that elevation it will give the "height of instrument."

A fore sight is a rod reading taken on a point of unknown elevation. If subtracted from the "height of instrument," it will give the elevation of the point.

66. What are intermediates and why are they taken in leveling?

They are readings taken between regular stations where the line changes direction or where the natural surface of the ground changes slope, so that when plotted the levels will show a true profile of the line.

67. What is the quickest way of setting up a level on a side hill?

Set one of the legs up hill and the other two down hill.

68. In setting up a level how do you know when you are about the right height?

Stand the level up with the tripod legs together and sight along the telescope with the bubble approximately in the middle and observe where the line of sight strikes with reference to the rod. This will enable one to judge very closely.

69. What is a spirit level and what is it used for?

A spirit level is a glass tube filled with some spirit, such as alcohol, except for a bubble of gas, which rises to the centre when the

tube is horizontal. It is used to get a horizontal line, and is attached to transits, levels, etc., for this purpose.

70. What is a transit used for?

A transit is used for measuring angles and running lines, and for leveling when long bubble is attached.

71. What is the safest way of carrying an engineer's transit or level to prevent accident or derangement under every condition?

The instrument should be carried in its box, care being taken that the clamps are tight, allowing no motion.

72. What is the best way to carry a transit through brush?

Carry the transit under your arm with its head forward.

73. Describe how you would cut a bench mark on the root of a tree.

Select a portion of the root facing the line of work on which the rod can be held vertically without interference by limbs. Cut the root so as to leave a projection on which the rod can be freely rotated. Drive a spike into the root. Blaze the bark above the point and mark upon it "B. M." and the elevation of the point.

74. (*a*) If called upon to set up a transit, what points are particularly to be attended to?
(*b*) Would you screw the leveling screws very tight or how?

(*a*) The head should be screwed snugly on the tripod, the lower clamp being loose.
The legs should be set firmly in the ground.
The plate should be approximately level, and at a convenient height.
The plumb bob should swing approximately over the point, so that it may be brought exactly over it by means of the "shifting centre."
(*b*) The leveling screws should be made snug, but not tight enough to bind.

75. What is the difference between a rod used for a transit survey and one used for a level survey?

The rod used for a transit survey is comparatively thin, made of wood or iron, round or hexagonal in shape, and about 6 to 10 ft. long, each foot being painted alternately with contrasting colors.

It is used for sighting and ranging in lines. The level rod is rectangular in shape, about $6\frac{1}{2}$ ft. long, sliding out to 12 ft. It is usually graduated to feet, tenths and hundredths, and provided with a target, having attached vernier, enabling one to read to thousandths.

76. Assume that the engineer sent you to the office to bring everything necessary for a transit survey, what would you bring?

Transit, two sighting rods, axe, brush hook, stakes and a bag containing field book, one 100-ft. and one 50-ft. tape, three plumb bobs, hammer, chisel and punch, string, crayon, and tacks.

77. How many stakes would be required to give stations on a transit line half a mile long, allowing 7 for plus stations, including the last stake?

Thirty-four stakes.

78. How would you clean a rusty tape?

Give tape a vigorous rubbing with a cloth soaked in kerosene or benzine. Rub with fine emery cloth or emery powder until all rust is removed. The tape can then be polished with dry cement or some suitable metal polish, such as "Putz."

Mathematics.

79. Write decimally ten thousand and seven and forty-three ten-thousandths.

10007.0043.

80. Write decimally one million twenty-three thousand eighty and thirty-thousandths.

1023080.030.

81. Write in words 3,099,077,009.0321.

Three billion ninety-nine million seventy-seven thousand nine and three hundred twenty one-ten-thousandths.

82. Subtract by fractions and by decimals $\frac{3}{8}$ from $\frac{12}{16}$.

By fractions:

$$\frac{12}{16} - \frac{3}{8} = \frac{6}{8} - \frac{3}{8} = \frac{3}{8}$$

By decimals:

$$\tfrac{12}{16} - \tfrac{3}{8} = 0.75 - 0.375 = 0.375.$$

83. Add $\frac{3}{5}$, $\frac{5}{8}$, $1\frac{1}{16}$, $\frac{7}{15}$, $\frac{3}{10}$.

Find Least Common Denominator.

$$\begin{array}{r|l} 5 & 5 - 8 - 16 - 15 - 10 \\ \hline 2 & 8 - 16 - 3 - 2 \\ \hline 2 & 4 - 8 - 3 - 1 \\ \hline 2 & 2 - 4 - 3 \\ \hline & 2 - 3 \end{array}$$

$$5 \times 2 \times 2 \times 2 \times 2 \times 3 = 240 \text{ L. C. D.}$$

$$\begin{aligned} \tfrac{3}{5} &= \tfrac{144}{240} \\ \tfrac{5}{8} &= \tfrac{150}{240} \\ 1\tfrac{1}{16} &= \tfrac{255}{240} \\ \tfrac{7}{15} &= \tfrac{112}{240} \\ \tfrac{3}{10} &= \tfrac{72}{240} \\ \hline \tfrac{733}{240} &= 3\tfrac{13}{240} \end{aligned}$$

84. Divide 2 and $\frac{1}{2}$ by $\frac{4}{5}$, multiply by $\frac{3}{8}$, add $\frac{3}{4}$ and substract $\frac{1}{2}$. What is the result?

$$2\tfrac{1}{2} \div \tfrac{4}{5} \times \tfrac{3}{8} + \tfrac{3}{4} - \tfrac{1}{2} =$$

$$\tfrac{5}{2} \times \tfrac{5}{4} \times \tfrac{3}{8} + \tfrac{3}{4} - \tfrac{1}{2} = \tfrac{75}{64} + \tfrac{48}{64} - \tfrac{32}{64} = \frac{75 + 48 - 32}{64} = \frac{91}{64} = 1\tfrac{27}{64}.$$

85. If $3\frac{3}{4}$ is $2\frac{1}{2}$ times a certain number, what is $3\frac{1}{8}$ times the same number?

$$\begin{aligned} 2\tfrac{1}{2} \times \text{number} &= 3\tfrac{3}{4} \\ \text{or} \quad \tfrac{5}{2} \times \text{number} &= \tfrac{15}{4} \\ \text{Therefore Number} &= \tfrac{15}{4} \div \tfrac{5}{2} = \tfrac{15}{4} \times \tfrac{2}{5} = \tfrac{3}{2} = 1\tfrac{1}{2} \\ \text{and } 3\tfrac{1}{8} \text{ times } 1\tfrac{1}{2} &= \tfrac{25}{8} \times \tfrac{3}{2} = \tfrac{75}{16} = 4\tfrac{11}{16} \end{aligned}$$

86. What number added to $\frac{7}{9}$ of $18\frac{3}{4}$ will equal $\frac{9}{10}$ of $41\frac{2}{3}$?

$$\tfrac{9}{10} \text{ of } 41\tfrac{2}{3} = \tfrac{9}{10} \times \tfrac{125}{3} = \tfrac{375}{10} = \tfrac{75}{2}.$$

$$\tfrac{7}{9} \text{ of } 18\tfrac{3}{4} = \tfrac{7}{9} \times \tfrac{75}{4} = \tfrac{525}{36} = \tfrac{175}{12}.$$

$$\tfrac{75}{2} - \tfrac{175}{12} = \tfrac{450 - 175}{12} = \tfrac{275}{12} = 22\tfrac{11}{12}.$$

87. If a laborer can reap a field of grain in $4\frac{4}{5}$ days, how long would it take 4 laborers to reap a field $6\frac{1}{4}$ times as large?

Four laborers will reap same field in $\frac{1}{4} \times 4\frac{4}{5}$ days $= 1\frac{1}{5}$ days. Since the field is $6\frac{1}{4}$ times as large, it will take $6\frac{1}{4} \times 1\frac{1}{5} = \frac{25}{4} \times \frac{6}{5}$ $= 7\frac{1}{2}$ days.

88. If a man can walk 200 miles in 9.375 days, how far at the same rate can he walk in 15.625 days?

In one day he will walk $\frac{200}{9.375}$ miles.
In 15.625 days he will travel $\frac{200}{9.375} \times 15.625$ miles $= \frac{1000}{3} =$ $333\frac{1}{3}$ miles.

89. A church is 85.64 ft. long, 51.28 wide and 31.5 ft. high to the eaves. Find cost of painting outside walls at 34 cents per sq. yd.

$$\text{Cost} = \left(\frac{85.64 \times 2 \times 31.5}{9} + \frac{51.28 \times 31.5 \times 2}{9}\right) \times \$0.34$$

$$= \left((85.64 + 51.28)\,\frac{2 \times 31.5}{9}\right) \times\ .34 = \$326.87.$$

Calculations shown at right.

$$\begin{array}{r} 85.64 \\ 51.28 \\ \hline 136.92 \\ 7 \\ \hline 958.44 \\ .34 \\ \hline 393376 \\ 287532 \\ \hline \$326.8696 \end{array}$$

90. A field is 56 rods wide—contains 25 acres 88 sq. rods. Find cost of fencing at $66\frac{2}{3}$ cents a yard.

Area $= 25$ acres 88 sq. rods $= 25 \times 160 + 88 = 4088$ sq. rods.
Width $= 56$ rods. Therefore length $= \frac{4088}{56} = 73$ rods.
There will be $73 + 73 + 56 + 56 = 258$ rods $= 258 \times 5\frac{1}{2} = 1419$ yards of fencing.
Cost will be $1419 \times 66\frac{2}{3}$ cents $= 1419 \times \$\frac{2}{3} = \frac{2838}{3} = \$946.90$.

91. If $9\frac{3}{8}$ yd. cloth cost $\$26\frac{1}{4}$, how many yards could be bought for $\$24\frac{4}{5}$?

One yard will cost $\dfrac{26\frac{1}{4}}{9\frac{3}{8}} = \dfrac{\frac{105}{4}}{\frac{75}{8}} = 7 \times \frac{2}{5} = \frac{14}{5} = \$2\frac{4}{5}$ cost per yard.

For $\$24\frac{4}{5}$ we can buy $\dfrac{24\frac{4}{5}}{2\frac{4}{5}} = \dfrac{\frac{124}{5}}{\frac{14}{5}} = \frac{124}{14} = \frac{62}{7} = 8\frac{6}{7}$ yards. *Ans.*

92. Four men working 8 hours each can shovel 128 cu. yd. of earth; how many cubic yards of earth can 8 men shovel if they work 12 hours each at the same rate?

1 man can shovel in one hour $\frac{1}{4} \times \frac{1}{8} \times 128 = \frac{128}{32} = 4$ cu. yards.

Therefore 8 men working 12 hours can shovel $8 \times 12 \times 4 = 384$ cu. yards.

MANUAL OF EXAMINATIONS

FOR

ENGINEERING POSITIONS

IN THE

SERVICE OF THE CITY OF NEW YORK

QUESTIONS AND ANSWERS
IN 3 VOLUMES

VOL. I. AXEMAN, CHAINMAN AND RODMAN, LEVELER, AND TRANSITMAN AND COMPUTER

VOL. II. ASSISTANT ENGINEER

VOL. III. DRAFTSMAN AND INSPECTOR

VOL. I. PART II.
CHAINMAN AND RODMAN

INDEX

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1906

J. F. TAPLEY Co.
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NEW YORK

PREFACE.

In the "Previous Examination Papers" which have been included in this book, the questions may not, in all cases, be identical in wording with those actually given at the examinations, as copies of the original papers are not readily procurable, but they do embody the substance of the questions asked.

In the section devoted to "Typical Questions and Answers," the answers indicate in a general way only what is required of the candidate, and are not intended to be perfect and complete, as reasonable variance of opinion may exist as to what is the best answer in many cases, owing to differences in interpretation of the question and in education and experience.

In order to perpetuate the value of this book, blank leaves have been inserted after the "Previous Examination Papers," allowing for the convenient addition of new sets, and the "Typical Questions and Answers" have been interleaved, to provide space for notes, sketches and additions.

PREVIOUS EXAMINATION PAPERS.

CHAINMAN AND RODMAN.

Salary, $900 to $1 200 per annum.

Technical.

1. Suppose you are measuring a practically level line a mile long, state exactly all you would do, and especially how the tally would be kept.

2. In measuring up hill, how does the rear chainman hold steadily at the right point? Does he ever touch the stake; and, if so, why?

3. Where the surface is very steep what is done in chaining and what precaution should be taken to prevent wrong tally being made?

4. Suppose a survey has been made of a lot of which all the corners were definitely fixed before the survey, and the chain is found to be long, how should the notes be corrected?

5. State all the ways in which errors may be introduced or caused in chaining.

6. Suppose the bank of a river is to be located from field notes, how would the work be done by the chainman?

7. How would you measure past a tree on a line and produce the line in practically the same direction without an instrument?

8. Suppose a piece of ground to have two sides parallel but of unequal length (in other words, trapezoidal in form), how would you measure it and compute the area?

9. (*a*) Explain the construction of a vernier on a leveling rod. (*b*) For what purposes is it desirable to use the vernier, or do you consider it essential to always read to thousandths of a foot?

10. Suppose the rod to be extended to 10 ft., figure how much out of plumb it must be to make an error of one-thousandth in the reading?

11. State all the means made use of by rodmen to keep the rod plumb.

12. State all the means made use of by a rodman to avoid errors in reading the rod.

13. State all the ways in which errors are made in connection with turning points, from every cause whatever.

14. State all the causes of errors in any way connected with the target aside from its reading.

15. State the considerations that should always govern a rodman in locating turning point.

Arithmetic.

1. (*a*) What is the difference between the square of $\frac{1}{2}$ of 32 and $\frac{1}{2}$ of the square of 32? (*b*) Extract the square root of $25.0\frac{3}{4}$, correct to 4 places of decimals.

2. The perimeter of a rectangular field in 140 rods; from 1 corner to the centre of the field is 25 rods; find dimensions and area.

3. On opposite sides of a stream 40 ft. wide stand two trees, 83 ft. and 57 ft. in height; what is the distance between the tops cf the trees?

4. A city lot cost $2 250 at 40 cents a square foot; its parallel sides were 39 ft. and 51 ft. respectively; what was the length of the lot?

5. A cylindrical column of granite is 13.09 ft. in circumference and its volume is 818.125 cu. ft. What is the height of the column?

Experience.

1. Have you taken a regular course of instruction in engineering in any college or technical school? If so, at what one? What was the length of the course and what degree or diploma, if any, did you receive?

2. If you have not taken such a course state what your education in engineering has been.

3. Have you followed any mechanical pursuit? If so what and for how long?

4. State what experience you have had as chainman or rodman or any higher or lower engineering position, particularly in city work.

5. If there are any other points that you consider important in your experience which would help you as a chainman or rodman, state them fully.

CHAINMAN AND RODMAN.

Technical.

October, 1900.

1. What is your age? Have you pursued any course of technical study; if so, what, where, when, and how—also did you graduate? What practical experience have you had in engineering work?

2. Describe method or methods pursued on the aqueduct work in measuring up steep ascent.

3. Describe method pursued in measuring down steep descent.

4. State two causes of error in chaining depending upon the weather or other natural causes, and how they may be either partly or wholly overcome.

5. State three other most prominent causes of error in chaining dependent upon the chainman and how they may be overcome.

6. In chaining up a hill, how can the rear chainman hold firmly to the point in plumbing?

7. In what ways may a wind blowing lengthwise of a chain offset the accuracy of the work in using it?

8. Make a careful sketch of a vernier of a leveling rod, and explain how it is possible to read to thousandths of a foot on a rod divided only to hundredths.

9. State what readings should be taken to thousandths, and also others in which tenths of a foot are sufficiently accurate.

10. Explain or illustrate the various ways in which Bench Marks are fixed on engineering works.

11. How can you be reasonably sure that you are plumbing the rod correctly in both directions?

12. How may you introduce error in the use of a New York rod when you have to extend it?

13. How can you expedite the work of a leveler and make it more accurate by care in the location of turning points?

14. In giving "rod" for an accurate sight, describe everything you would do.

15. What notes should a rodman keep?

PROMOTION EXAMINATION—RODMAN.

TECHNICAL.

JULY 19, 1901.

1. (*a*) What educational training have you had which fits you for the position of Rodman? (*b*) What practical experience have you had?

2. Make a sketch of a vernier on a rod, and show how thousandths of a foot can be read.

3. Describe all the ways in which mistakes are made in reading a rod, after the target is set.

4. (*a*) Does a rod held out of plumb make the rod reading on a point too great or too small, and why? (*b*) How may this fact be made use of in plumbing a rod?

5. What errors may arise from lack of care in setting the target?

6. What notes, if any, should a rodman keep? Give a specimen in pencil of your best form.

7. Does the location of a turning point by a rodman require any special care or thought on his part, and, if so, what considerations govern this?

8. How would you fix a transit point on a center line in a tunnel?

9. How would you transfer a level from a given point on the surface to one in the tunnel?

10. In doing accurate measuring with a steel tape, how are temperature changes provided for?

11. Aside from providing for temperature changes, what four sources of error must be provided against?

12. What is the best method of holding the rear end of a chain steady, when it is necessary to hold over a point at that end?

13. In running a transit line very carefully and setting a fore-sight from a back-sight, is more than one sight given the flagman, or how is it done?

14. In chaining on a long line, what method do you pursue, to be sure that no mistakes are made in tallying?

15. Why is it necessary in doing careful leveling to make the back-sights and fore-sights equal?

CHAINMAN AND RODMAN.

Technical.

1. State what points a rodman should keep a record of the reading on, and give a sample of such notes.

2. State all the difficulties a rodman has to contend against in trying to do good work in the city.

3. (*a*) In what way does the sun affect the work? (*b*) How does wind affect the work of leveling? (*c*) How may frost, ice, snow, etc., affect it?

4. Describe the characteristics of a thoroughly good turning point; also of a poor one.

5. In what ways are errors caused by a rodman being careless or not understanding his business fully?

6. Does it make any difference in the progress of work as to how the rodman locates turning points? And if so, state how.

7. Sketch a vernier on a rod and explain how it is that thousandths of a foot can be read by it.

8. What fraction of an inch is one-thousandth of a foot equal to?

9. Describe the sights used in running transit lines for back-sighting to.

10. Name five things requiring close attention in making accurate measurements with tape or chain.

11. How does the heat of the sun affect a tape, and how is this compensated for in the use of an engineer's tape?

12. Describe clearly and fully the duties of a rear chainman in measuring up a hill.

13. How can the rear chainman hold the tape steady over a point?

14. (*a*) Describe the duties of a forward chainman. (*b*) How is the record of chain-lengths kept?

15. State all the difficulties that tend to introduce error in the work of chaining.

1. Find the square of $201\frac{39}{200}$. Find the square root of 3053.172 correct to four places of decimals.

MATHEMATICS.

2. A street a quarter of a mile long has on each side a sidewalk $7\frac{1}{2}$ ft. wide; what will it cost to pave this sidewalk (both sides) with stones each 2 ft. 9 in. long by 1 ft. 8 in. wide and costing 75c.?

3. Two vessels sail at the same time from the same place, one sailing due east and the other due north, at the rate of 6 miles and 8 miles an hour, respectively. How far apart will they be at the end of 12 hours?

4. A man paid $2 262 for a field in the shape of a trapezoid. The parallel sides were 119 yd. and 200 yd., respectively, the distance between them 110 yd. What did the land cost him by the acre?

5. How many square yards in a graveled walk 6 ft. wide, running around a circular fish pond whose diameter is 70 yd.?

CHAINMAN AND RODMAN.

Technical.

(1904.)

1. Describe briefly and state the difference between the rods used in transit, level and stadia work.

2. (*a*) To which of the above kinds of work does the rule "foresights and backsights must be equal" apply? (*b*) What is the reason of above-named work?

3. Why should the rod be held plumb? State the different reasons for each kind of above-named work.

4. Assume an inch divided into quarters; describe and show by sketch a vernier which will divide it into twentieths.

5. State the several ways in which a good rodman can facilitate the work of leveling.

6. (*a*) In leveling, why should a rod be waved to and fro? (*b*) Would it do to wave it from side to side provided it was always in a plane perpendicular to the line of sight? Give reasons.

7. What part of an inch is a thousandth of a foot?

8. If a level is out of adjustment and reads an error of .03 at 100 ft., what will the error be at 400 ft. distance?

9. (*a*) How can you lay off a right angle with a chain? (*b*) How with a piece of cord?

10. Describe fully the work of the two chainmen in chaining for levels up a steep hillside.

11. In the use of a tape, what four important points must be observed to get accurate results? State in their order of importance.

12. (*a*) Why is the Gunter's chain used for farm surveys? (*b*) Why the steel tape for city work?

13. In leveling, what errors, which affect the accuracy of results, are due to a rodman's lack of care?

14. State every way in which the reading of a rod should be checked.

15. If the wind was blowing hard, state every precaution you would exercise in measuring a line where considerable accuracy was desired.

Mathematics.

1. Reduce the following to thousandths of a foot, 7 ft. 9 in., 6 and 7/10 ft., 42 in., 12 and 607 thousandths ft. and 17 and $\frac{3}{8}$ in.

2. Four men can shovel 9 yd. of gravel per hour; how long will it take 50 men to shovel 4 500 yd. of gravel, working 8 hr. a day?

3. What is the contents in cubic yards of a retaining wall which has one face vertical and is 123 ft. long; one end is 18 ft. high, base 10 ft., top 2 ft., and the other end is 12 ft. 6 in. high, base 7 ft. 6 in. and top 2 ft.? (The prismoidal formula may be used, but is not required.)

4. If a rod has the target at 8.23 ft. and is 4 in. out of plumb, how much of an error in thousandths is made in the elevation?

Experience.

1. Have you taken a regular course of instruction in engineering in any college or technical school? If so, what one? What was the length of the course and what degree or diploma, if any, did you receive?

2. If you have not taken such a course, state what your education in engineering has been.

3. Have you followed any mechanical pursuit? If so, what and how long?

4. State what experience you have had as chainman or rodman, or any higher or lower engineering position, particularly in city work.

5. If there are any other points that you consider important in your experience which would help you as a chainman or rodman, state them fully.

PROMOTION EXAMINATION—RODMAN.

TECHNICAL.

(Bronx.)
JULY 28, 1905.

1. (*a*) What is the difference between an "inch" and a "tenth?" (*b*) What between a square yard and 3 sq. ft.?

2. (*a*) How many feet are there in a Gunter's chain? (*b*) Why was this adopted as a standard of measurement?

3. If a tape were tested and found to be 99.98 ft. and a measurement had been made with it giving 1 500 ft., what would be the correct distance?

4. Explain 2 ways of laying off a right angle with a tape?

5. If a rod is divided into 10ths and you wish to read it to 50ths explain and show by sketch how a vernier would be constructed to do it.

6. In leveling. (*a*) Why should a rod be waved to and fro? (*b*) Why should a second sight be given?

7. Why should backsights and foresights be equal? Explain answer in detail.

8. Explain method of setting slope stakes for an embankment with slopes of 1 to 1.

9. In what particulars should a rodman be more careful in using an extended rod than a low rod?

10. Describe fully a rodman's work in accurately setting a transit point to be located on a stake.

11. In making accurate measurements with a tape, name 5 important things requiring attention.

12. (*a*) What are the duties of a rodman on a stadia survey? (*b*) Describe the rod used.

13. What are the requirements in common of a turning point and a bench, and in what respects may they differ?

14. Describe how, by the use of a chain alone, you would measure an angle so it could be mapped from your notes.

15. Show a set of notes of B. M.'s and T. P.'s such as a rodman would keep on a bench run.

CHAINMAN AND RODMAN.

Technical.

October 19, 1905.

1. How do the duties of a rodman differ in surveys with (*a*) a level; (*b*) transit; (*c*) transit with stadia?

2. What are contour lines? How are they obtained?

3. (*a*) A cubic foot of water contains how many gallons? (*b*) Weighs how much?

4. How is the velocity of flow of a stream measured?

5. (*a*) What is the difference in decimals of a foot between 9.66 in. and .572 ft.? (*b*) Express thirty-six thousandths of a foot in decimal figures. (*c*) Turn 94.86 in. into feet and decimals of a foot and express the result in words.

6. Assume that a New York rod can be clearly seen at a proper distance. What must the rodman do to assure a correct reading?

7. The distances between sights on a bench run are as follows: B. S., 450 ft.; F. S., 200 ft.; B. S., 600 ft.; F. S., 300 ft.; B. S., 140 ft.; F. S., 300 ft.; B. S., 150 ft.; F. S., 300 ft.; B. S., 50 ft.; F. S., 300 ft. Will there be any error from curvature? Give your reasons.

8. Describe how by the use of a chain alone you can measure an angle in the field so it can be mapped.

9. A target set on a rod at 5.00 ft. is 0.3 ft. out of plumb. How much difference will it make in the elevation read as compared with the correct elevation?

10. Explain how each of the following points necessary to be observed in accurate measurement with a tape are attained; level, tension, temperature, alignment.

11. How would you establish and mark a first-class bench on the root of a tree?

12. In making a long measurement what is the best method of keeping accurate tally of the number of chain or tape lengths?

13. Explain the principle of the vernier and illustrate by a sketch showing a reading of 2.424 ft.

14. Describe two methods of turning a right angle offset by use of a chain alone.

15. In accurately measuring a base line for triangulation, what special precautions are taken?

Mathematics.

Give all the figuring on the ruled sheets.

1. What is the area of a trapezoid of which the two parallel sides are 127 ft. 8 1-3 in. and 55 ft. 6 in., and the distance between them is 42 ft. 3 in.?

2. Add 19 ft. $6\frac{1}{2}$ in., 13 ft. $3\frac{1}{4}$ in., 7 ft. $2\frac{3}{4}$ in., 19.75 ft., 27.667 ft., 3.5 in., 66 in. and 196 in. and express the result in (*a*) feet and inches; (*b*) feet and decimals of a foot, and (*c*) inches.

3. A pipe 4 ft. inside diameter, running full, discharges into a canal 5 ft. wide with vertical sides; how deep will the water be in the canal?

4. A rectangular field contains $1\frac{1}{4}$ acres and is $3\frac{1}{8}$ times as long as it is wide; what are the dimensions of the field?

5. Three measurements added together give 2 400 ft.; the longest is 1 100 ft. more than the shortest and the other is 1 100 ft.; how much is the longest and how much is the shortest?

PROMOTION TO CHAINMAN AND RODMAN.

NOVEMBER 2, 1905. President Borough of Brooklyn.

1 to 3. Demonstrate your ability to write a clear, concise statement and your fitness for promotion by a suitable statement of your age, education and experience.

4. What are curvature and refraction and what relation do they bear to each other?

5. What can a rodman do in his work to eliminate the effects of curvature and refraction?

6. Describe the appliances on a tape where extreme accuracy of measurement can be had.

7. What points other than the proper use of such appliances must be observed to do accurate measuring?

8. When a rodman sets a high rod what check should he observe in order to be sure his setting and reading of the rod is correct?

9. Assume two lines intersecting at an acute angle, how could you make measurements with the tape alone so that the angle could be correctly drawn on a map?

10. In measuring a line a mile long, on city streets, how closely should two independent careful measurements agree?

11. (*a*) In a stadia survey what are the duties of a rodman? (*b*) Same in a line survey with a transit.

12. How does a self-reading rod differ from a New York rod?

13. (*a*) How would going down a hill affect your choice of T.P.'s? (*b*) How would it affect the chaining?

14. Assume a rod with target set at 8 ft. to be 0.3′ out of plumb, how much difference will it make in the elevation read as compared with the correct elevation?

15. A piece of property 500 ft. wide is to be divided into 5 lots of unequal width. Beginning at the narrowest, each to be 5 feet wider than the one before it. Find the width of the lots.

MANUAL OF EXAMINATIONS

FOR

ENGINEERING POSITIONS

IN THE

SERVICE OF THE CITY OF NEW YORK

CHAINMAN AND RODMAN

TYPICAL QUESTIONS AND ANSWERS

CHAINMAN AND RODMAN.

Typical Questions and Answers.

1. State fully what you consider the duties and requirements of a rodman to be.

His duties and requirements are:

To "run" the rod, take readings and keep record of same as a check upon the leveler's notes.

To select and fix T.P.'s and B.M's.

To act as chainman, set and mark stakes, etc.

To set up instruments.

To take the place of the leveler in the latter's absence.

To assist in carrying instruments, tools, etc.

To assist in calculations, office work, etc.

He should be familiar with the principle of leveling, understand the sources of error in his work, and avoid them as much as possible. He should know the rudiments of trigonometry, be able to use logarithms and assist in earthwork and other calculations.

2. What are the duties of a chainman?

The chainman runs the chain, reads it and keeps tally of the chain lengths. He should know the sources of error in his work and avoid them as much as possible; he directs the axeman in clearing lines for chaining, and the stakeman in driving stakes, assists in carrying instruments and acts as rodman when required.

3. How do the duties of a rodman differ in surveys with (*a*) a level; (*b*) transit; (*c*) transit with stadia?

(*a*) In leveling the rodman runs the leveling rod, selects and fixes T. P's. and keeps record of rod readings as a check on the leveler.

(*b*) In transit surveys, the rodman gives line with the sighting rods, plumb-bobs, etc.; acts as chainman; sets, marks and references stakes.

(*c*) In stadia work the rodman "runs" the stadia or self-reading rod, giving the transitman sights at every point, the location of which is desired, such as fence and building corners, tops of ridges, bottoms of hollows, breaks in contours, etc.

4. How many men are required to make up a surveying party?

For railroad or similar work:

Transit Party.	1 Chief of party.	Level Party.	1 Leveler.
	1 Transitman.		2 Rodmen.
	2 Chainmen.		1 Topographer and Recorder.
	1 Axeman.		
	2 Flagmen		

For city surveys:
1 Chief of Party; 1 Instrumentman, 2 Chainmen and 1 Axeman make a good working party.

5. Describe a Gunter's and Engineer's chain.

The Gunter's chain is 66 ft. long, and contains a hundred links, each link (including half the connecting rings) being 7.92 in. in length. It is made of steel or iron, the connections being brazed to reduce wear. Its length makes it convenient for use in surveys where the acre is the unit of measure, 10 sq. chains being equal to one acre.

Brass tags are attached, marking each 10 ft. of the length.

The Engineer's chain is similar in construction to the Gunter's. It is, however, 50 or 100 ft. long, each link, including connecting rings, being 1 ft.

6. What is the length of the link compared with a foot, how many inches and decimals?

In the Gunter's chain the link = 7.92 in.
In the Engineer's chain, the link = 12.00 in.

7. Why is a link chain not reliable?

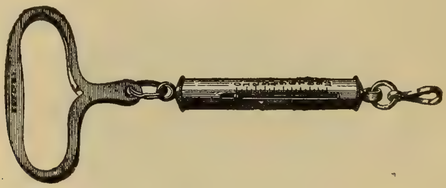
The link chain has too many wearing parts, rendering it liable to change in length. Links are apt to be deformed. It is heavy and sags considerably. Foreign objects, such as grass and weeds, get between the links, affecting the measurements. The chain is not graduated to enable close readings to be taken.

8. What sources of error are likely to arise in the long use of a chain which is not likely to occur with a tape?

The sources of error are wearing of the links at their connections and change in their lengths caused by bending or stretching.

9. What is the use of a spring balance applied to one end of a tape?

The spring balance is used to give a uniform tension to the tape at each measurement. The amount of tension should be sufficient to overcome the effect of sag, and is determined by comparison with a standard. The level bubble sometimes attached to the balance indicates whether tape is horizontal.



10. What is the most accurate instrument you know of?

(The answer to this question will depend entirely on the individual knowledge of the applicant. It may be a transit with some, a tape with others, etc.)

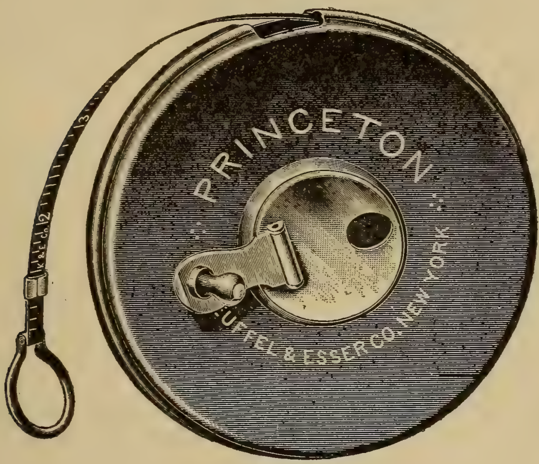
11. What are the different kinds of tapes you know of? Describe them and state where used.

The tapes most commonly used are:

(*a*) 50 and 100 ft. metallic or cloth tapes, used for rough work, such as cross sectioning.

(*b*) 50 and 100 ft. steel ribbon tapes graduated to feet, tenths and 100ths, standard usually, at 62° F., used for fairly accurate work.

(*c*) 50, 100, 200, 300 ft. steel wire tapes about 3/16 in. wide usually not graduated and provided with spring balance level and thermometer attachment. These are used for very accurate traverse and base line work.



12. Would you test the length of a chain?

Yes, where accuracy is required.

13. Are measuring instruments (tapes) likely to change? If so, how would you test them?

Yes, they *are* liable to change. Would test them by comparison with a standard tape whose length is accurately known, or with some fixed standard.

14. In testing a tape or chain by a fixed standard, is there anything else to be considered other than level and temperature, and if so, what and how is this secured?

The atmospheric conditions must be considered. There should be no wind, the temperature should be uniform, there should be sufficient light to read the tape accurately.

The tension to be applied and method of supporting and reading the tapes must be considered, so that fine adjustment can be obtained.

These conditions may be secured by setting two monuments in the ground enclosed in a brick building and determining the distance between points set in them very accurately. They should be a tape length apart as near as can be set.

At one end another point should be set accurately at right angles to the line of the monuments. Provision should be made for supporting the tape at each end, and by means of a screw or turnbuckle to allow a slight motion of the tape. The zero of the tape is brought accurately over the point; and a transit, set up on the offset point and sighted on the monument determines the correct length of the tape. By means of an auxiliary scale the excess or deficiency of the tape is measured.

15. In comparing with an official standard, would you lay the measure down or would you suspend it?

I would suspend it.

16. Describe manner of using chain with spring balance and level attachment; explain use of spring balance and level.

The bubble is used to bring the tape horizontal. The metal barrel which encloses the bubble is arranged so as to enable it to be adjusted to the temperature indicated by a thermometer (attached or detached). The end of the tape is marked by a groove on the balance. An index on the balance indicates when the required pull is obtained. This pull should be uniform for each tape length. The rear chainman plumbs the zero over the rear point and the head chainman watches the bubble, the balance and his plumb bob, and applies the required pull. When the bubble is in the centre and the rear chainman and transitman have both signalled o. k. he fixes the forward point, which is then checked, and the chain carried ahead. The balance should be set for the temperature on starting work and adjusted when required.

17. State exactly how tally is kept of chain lengths and how errors may be made.

Tally of chain lengths may be kept by means of chaining pins. The front chainman is supplied with nine plain and one marked pin. At the end of each chain length he leaves a pin, which is picked up by the rear man, the tenth chain length being marked with the special pin. When the rear man has picked up all the pins he turns them over to the head man, showing that 10 chain lengths have been measured. Tally may also be kept by marking the number of chain lengths on stakes or stones placed beside the points, or by keep-

ing record in a note book, in which case the rear chainman should call out the back station, the head man calling out the forward one. When pins are used errors may be made by forgetting to pick up pins, by losing same, or by putting them in by mistake. When pins are not used errors are usually made by carelessness in marking and calling off the stations. Tally may also be kept by means of an indicator made for the purpose.

18. Where very accurate chaining is required, are pins used for fixing the points? Describe the best methods.

Pins are *not* used for fixing points in accurate work. In open country the points may be marked by fine tacks driven into stakes or marks may be made on chaining plates provided for the purpose. On city streets chaining plates may be used, or fine scratches made on the pavement. Chaining plates which can be readily adjusted to line and grade afford the best means for marking points where great accuracy is required.

19. What use do you make of a plummet in chaining?

A plummet or plumb bob is used to transfer a point on the tape to a point on the ground vertically beneath and, conversely, to obtain a point on the tape vertically over a point on the ground. It is also used for "line" and as a guide to the chainman in holding the tape horizontal.

20. State all the sources of error in chaining which may arise from natural causes or carelessness.

Errors due to natural causes arise from:

Temperature changes—causing expansion and contraction of tape.

Wind—making it difficult to hold tape or bob steadily or accurately, and causing shortening of chain length owing to lateral swaying of tape.

Errors due to carelessness arise from:

Not holding correctly over points.

Interference with bob or bob string.

Tape not being on line.

Not holding horizontally and steadily.

Not applying proper tension.

Kinks in tape and interference with it.

Poor or ill defined points.

Errors in keeping tally and reading plusses.

21. Should measurements with a chain be made horizontally; if so, for what reasons?

They should either be made horizontally or reduced to the horizontal if measured on a slope. Because the map or plan of a survey is the horizontal projection of the points in the survey, and horizontal measurements give the projected distances for plotting.

22. How do you make them horizontally?

The tape is brought to the horizontal position by means of a spirit level or by judging the *right-angle* between the tape and plumb bob string. Experience will enable one to judge closely.

23. State two causes of error in chaining depending upon the weather or other natural causes, and how they may be either partly or wholly overcome.

(*a*) Lateral swaying of tape due to wind partly overcome by "breaking chain," that is, by measuring in partial chain lengths and by shielding both tape and bobs.

(*b*) Expansion and contraction of tape due to changes in temperature overcome by applying the proper temperature correction to the measured length, or by using compensating attachment.

24. State three other most prominent causes of error in chaining, dependent upon the chainman, and how they may be overcome.

1. Not holding tape horizontal, and inaccuracy in holding over points.

2. Not applying proper tension, kinks and obstruction.

3. Errors in reading tape.

Errors No. 1 and 2 may be overcome by exercise of proper care, and repeating measurement. Error No. 3 can be eliminated by checking readings.

25. What are the several ways in which wind affects the accuracy of chaining?

It increases the measured distance owing to the lateral swaying of the tape. Disturbance of the tape and bob makes it difficult to hold accurately and st adily over a point.

26. If in measuring up a hill the chain be laid on the ground, how will the distance obtained be affected? State two ways by which the error in the work may be eliminated.

The measured distance will be too long. Errors may be eliminated by either measuring horizontally, "breaking chain" if necessary, or by measuring along the slope, ascertaining the differences of elevation between the measured points, and reducing the slope measurements to the horizontal.

27. In chaining down steep slopes how would you avoid possible error in carrying the distances along?

The tape is run out its full length. The rear chainman holds zero of tape over rear point, the front chainman calls out the partial distance measured, and marks the point on the tape with chalk. It getting the next measurement the rear chainman holds at the marked point, and the front chainman fixes the forward point as before. This operation is repeated until the entire chain length has been covered, when the chain is taken ahead and rear chainman holds again at the zero.

28. In chaining up a hill, how can the rear chainman hold firmly to the point in plumbing?

He can hold to the point by standing to one side of tape and bracing himself with one foot down hill and other foot firmly set on ground, the tape being held at the proper height, or he may use a rod set firmly in the ground as an aid in holding steadily to the point.

29. In good chaining, what other things must be attended to besides accurate plumbing?

Besides accurate plumbing, attention should be given to the following:

Proper tension should be applied.

The tape must be held steadily and not jerked.

Tape should be held horizontally and on line and be free from kinks and interference.

Correction for temperature should be made or compensating device used.

30. How does heat affect the length of a chain or steel tape? How is this allowed for in very careful work?

Heat lengthens the chain or tape. It is allowed for by adding to or subtracting from the measured length the correction due to the difference between the observed and standard temperatures of the tape, or by using a compensating attachment. (Tapes are usually standard at 62° F.)

The temperature correction for 1 ft. = .000006 of a foot for each degree Fahrenheit. For a 100-ft. tape and a change of temperature of 100° F. the correction equals .06 ft., or ¾ in.

31. If you had to measure a long line between two given points accurately, how would you proceed?

The transit is set up on one end of the line and directed on a fixed flag at the other end or on some intermediate point on line, previously established.

Start at the higher point and chain towards the lower, using entire chain lengths wherever possible. The rear chainman carries the zero end of the tape.

Run out the full length of the tape. Obtain line from transitman and smooth off the ground at the end of the chain length. Then observing bubble or bob string, hold tape horizontal and steady. Follow directions of transitman for line, apply given tension and at proper signals fix the forward point, taking care to make it as fine and distinct as possible. Repeat the measurement, and if it checks carry the chain ahead. The operation is repeated until the entire line has been measured. Where chain has to be "broken" the rear chainman should hold at the point previously held by front man.

The tally should be carefully kept and if possible marked on stones or stakes placed beside the points; all plus readings should be checked.

32. Describe fully the work of setting a stake on a transit line. How are such stakes marked?

The transitman gives line; the rear chainman plumbs the zero end of the chain over the rear point and the front chainman holding bob string on the tape, at the proper point, is set on line. When the transitman and rear chainman both signal o. k. the front chainman

indicates the point on the ground, where the axeman drives a stake. The measurement is then repeated carefully and the point is set on the stake at the required distance and on line. The tack is driven in the stake at this point and the line and distance of this tack is checked.

These stakes are marked with the number of the station from the beginning of the line, a full station being 100 ft. If not at a full station the plus distance from the preceding full station is also marked upon it.

33. When obliged to use a plumb-bob at rear end of chain or tape, state how you can secure accuracy of position and level.

Accuracy of position is secured by standing along one side of tape, holding tape firmly at proper height with one hand, the other hand holding bob string against the tape and over point; or better, by bracing yourself with the aid of a rod or other suitable support. The ring of the tape may be slipped over the rod and the tape set and held in position.

Accuracy in level is secured by means of an attached spirit level, or by judging the *right angle* between the tape and bob string.

34. In measuring up an incline, is there any better way for the rear chainman to hold his end of the chain to the point than by bracing himself so as to steady the plumb line? If so, describe it.

Yes.

By using a rod such as a transit flag, set firmly in ground behind point, but not close enough to disturb it, the tape being attached to rod so that it can be raised or lowered. The rod is held with one hand and moved into position so that bob held in other hand and at the required point of tape is exactly over point.

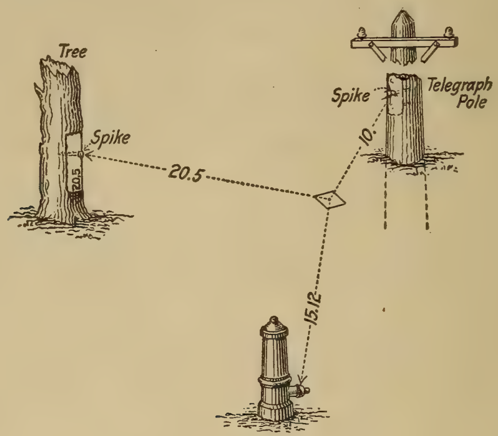
35. Suppose it to be necessary to be able in the future to relocate a point (in case the stake marking it be destroyed), what provisions are usually made by which this can be done?

The point should be referenced to two or more permanent objects close by, such as corners of buildings, hydrants, trees, etc.

The description of these reference points, and the distances and general direction to the point referenced should be recorded for future use.

In open country, where permanent points are not available, several offset stakes are set, preferably at right angles to the line,

and the distances to them are recorded. The original stake can then be readily replaced, if lost.



36. In running a transit line very carefully and setting a foresight from backsight is more than one sight given the flagman, or how is it done?

In running lines by back and foresights *more* than *one* sight is given the flagman. The work is usually done by the "double r versal" method (also called "double hubbing" or "double centering").

The transit is set accurately over point, levelled up and telescope turned on given backsight and clamped. The telescope is then "plunged" or "revolved" about its horizontal axis and a point set ahead. The instrument is then unclamped, revolved about its vertical axis and telescope again directed to the backsight, clamped and plunged, and a second point set ahead beside the first. The mean of the two points thus set is on true prolongation of the line.

37. (*a*) How would you fix a transit point on a center line in a tunnel?

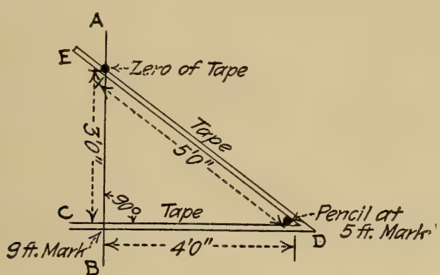
(*b*) How would you transfer a Bench Mark from a given point on the surface to one in the tunnel?

(*a*) When the tunnel is in rock, holes are drilled in the roof, and wood or metal plugs, provided with hooks for the suspension of plumb-bobs, are driven into the holes. Where timber bents are required to support the roof, nails or hooks may be driven in the timbers to fix the center line.

(*b*) First transfer the Bench Mark to a point on one of the shaft timbers at the surface. With the aid of a steel tape this B. M. is

transferred to the bottom of the shaft at a point vertically beneath, the bottom being prepared for the purpose. This tape measurement should be repeated several times and the mean taken, thousandths being estimated, or the B. M. may be transferred to the bottom by taking readings on the tape with the level set at the bottom of shaft. Using this new point as a Bench Mark the levels are run in the usual manner, establishing Bench Marks as conditions require.

38. If ordered to lay off a right-angled offset with a chain, how would you do it?

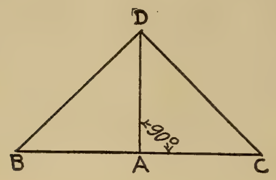


Let *A B* represent the line and *C* the point on it at which the offset is desired. Lay off 3 ft. from *C*, giving a point *E*. One man then holds the zero of tape at *E* and the 9-ft. mark at *C*. The tape is then pulled taut with a pencil held on the 5-ft. mark, which gives a point, *D*, on the offset line. Equi-multiples of 3, 4, 5, such as 6, 8 and 10; 12, 16 and 20, etc., may be used. The longer the distances used the greater the accuracy with which the offset may be laid off.

39. How else can you lay off a right angle with a tape or with piece of cord?

Double up the string in two equal portions, place the center at *A*, unfold and mark the points *B* and *C* on the line equi-distant from *A*. Then with one end of cord at *B* and other end at *C*, hold pencil at its middle point, pull it taut, and mark the point *D*. The line joining *A* and *D* will be at right angles to *B C*.

The tape may be employed in the same manner.



40. Describe how by the use of the chain alone you can measure an angle in the field.

Let $A\ B\ C$ represent the angle which it is required to measure.

Set a point D on line $A\ B$ and a point E on line $B\ C$.

Measure the distances $B\ D$, $B\ E$, and $D\ E$.

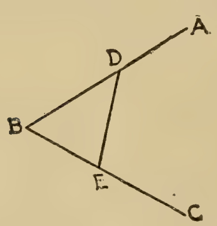
The angle B is then computed from the triangle $B\ E\ D$, all the sides being known.

If a, b, c represent the three sides and s half their sum, then

$$\cos. \tfrac{1}{2} B = \sqrt{\frac{s\,(s - b)}{a\,c}}$$

Or D and E are set equidistant from B and the tie line $D\ E$ measured.

$D\ E$ becomes the chord of a circle whose radius is $B\ D = B\ E$. Dividing $D\ E$ by $B\ D$ and looking up a table of chords the angle sought is obtained.



41. How would you measure past a tree, on a line and produce the line in practically the same direction without an instrument?

At some convenient point near the tree on line, a right-angle offset line is run (as explained in Question No. 38) and a point set at a measured distance. A second right angle is turned at this point, and a line run parallel to the original, until the obstruction is cleared. A third offset at right angles to the second is run and a point set at a distance equal to the first offset giving a point on the original line. This line can then be continued by turning a right angle at the point set from the last offset line.

42. What would you consider an allowable error in chaining 100 ft. and 1 000 ft.?

For rough work: 0.1 ft. in 100 ft.; 1.0 ft. in 1 000 ft.

In fairly good work the allowable error would be: .010 ft. in 100 ft. and 1 000 ft.?

For accurate traverse work: .002 ft. in 100 ft.; .02 ft. in 1 000 ft.

For long base line work: .001 ft. in 100 ft.; .01 ft. in 1 000 ft.

43. If a tape were tested and found to be 99.98 ft. and a measurement had been made with it giving 1 500 ft., what would be the correct distance?

Correct length $= 15 \times 99.98 = 1\,499.70$ ft.

44. Suppose you have measured the distance between 2 fixed points, and find it 1 000 ft. long, and that after your doing it you find for some reason your chain (which should be 100 ft. long), is too long by 1 in., what would be the correct length of line?

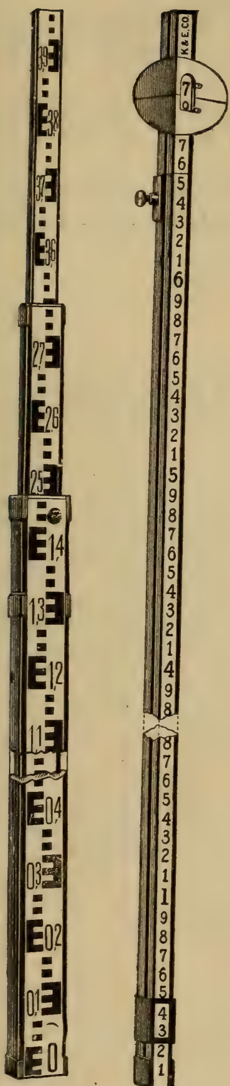
The correct length would be 1 000 ft. 10 in.

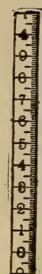
45. Suppose the quantity of ground in an existing lot which the city has to pay for depends on survey which was made with engineer's chain (not tape) which had been in use and had not been tested before making the survey, will the city probably pay more than it ought to or will it pay probably less for the lot?

The city will pay less than it ought to.

46. Suppose a survey had been made of a lot of which all the corners were definitely fixed before the survey, and the chain is found to be too long, how should the notes be corrected?

Add to each recorded measurement a correction equal to the error in the chain length, multiplied by the number of chain lengths in the measurement. Thus, if L = correct length, e = error in





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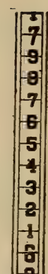
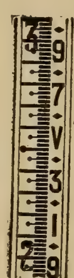


6254 & 5.
6260 & 1.
6267 & 8.



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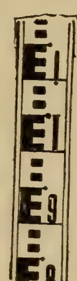


6251.

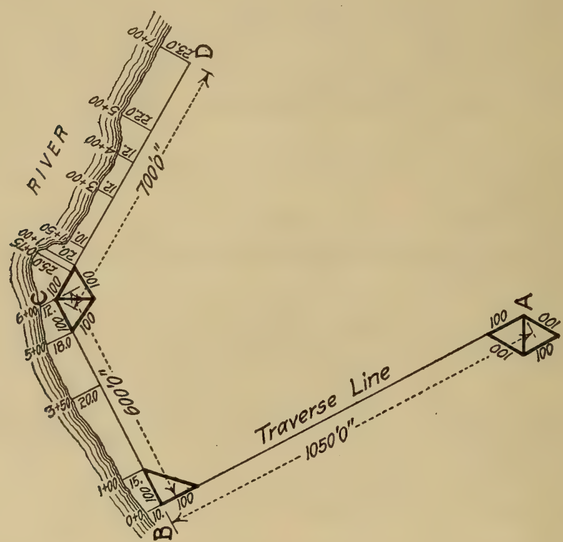
6284.
6285.

Leveling Rods.

chain length, and n = number of chain lengths in the measurement,

$$L = n + n\,e = n\,(1 + e).$$

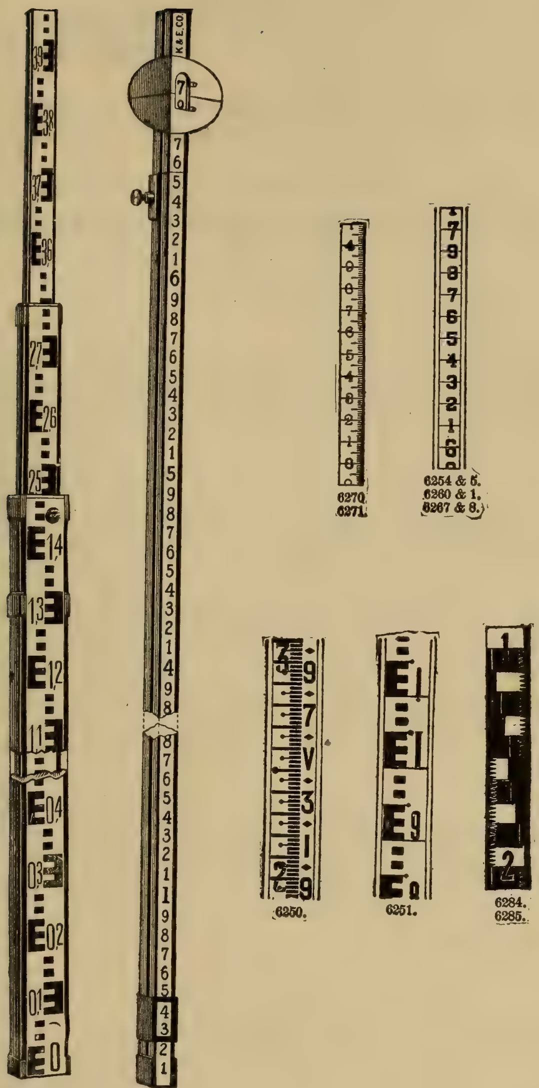
47. Suppose the bank of a river is to be located from field notes, how would the work be done by chainmen?



Traverse lines are run from some established point, A, towards the bank of the river, and deflected at points B, C and D, so as to run close to and follow the bank. The distance to each angle point should be obtained. The angles between the lines should be obtained with the transit if possible, or they may be computed from chain measurements of the heavy lines indicated in the sketch. To locate the bank, right-angled offsets to the traverse lines are taken at each "break" in the line of the bank. A tape is first stretched between consecutive stations along the traverse line. The chainmen then measure the shortest distance from the bank to the extended tape, obtaining at the same time the distance from the last angle point. From the measurements thus recorded the bank is located.

48. Describe the different kinds of leveling rods, commonly in use, state how they are graduated.

The New York rod is usually square, made in two sections, 6½ ft. long and sliding out to 12 ft. and provided with target having



Leveling Rods.

attached vernier—graduated to feet, tenths and hundredths, thousandths being read by means of the vernier.

The Philadelphia rod, $6\frac{1}{2}$ or 7 ft. long, sliding out to 12 or 13 ft., having target and attached vernier. Graduated into feet and tenths reading to .005 by vernier.

The Boston rod, $6\frac{1}{2}$ ft. long, sliding to $11\frac{1}{3}$ ft., provided with target and a vernier at each end. Graduated to feet, tenths and hundredths.

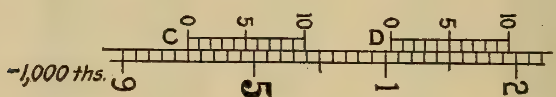
The self-reading, "speaking" or stadia rods of lengths from 6 to 18 ft., graudated so that they can be easily read at long distances.

49. (*a*) What is a vernier?

A vernier is an auxiliary scale sliding along the main scale, by means of which the smallest divisions of the latter can be subdivided.

50. Make a clear sketch of the New York rod so you can show how you can read to thousandths of a foot.

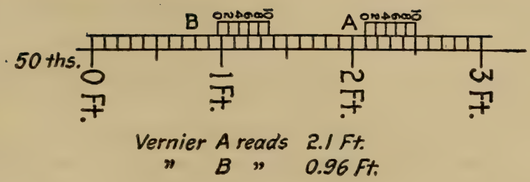
The vernier is graduated into 10 divisions, each being equal to .009 ft. or .001 ft. less than the smallest division on the rod. The division on the *vernier,* which exactly coincides with a division on the rod, shows the number of thousandths that the zero of vernier is above the next lowest graduation on rod.



Vernier C reads 4.95 Ft.
" D " 5.105 Ft.

51. If a rod is divided into 10ths and you wish to read to 50ths, explain and show by sketch how a vernier would be constructed to do it.

Four divisions (= 0.4) on the rod are transferred to the vernier on which it is divided into 5 parts. Each division on vernier will then be $\frac{1}{5}$ of $\frac{4}{10} = \frac{4}{50}$, or $\frac{1}{50}$ less than the 0.1 division of the rod.



The graduation on the vernier which coincides with a graduation on the rod will show the number of 50ths that the zero of vernier is above the preceding graduation on rod.

✓ 52. What is a bench mark and how should it be located? What is a T. P. and its object?

A bench mark is a permanent point whose elevation is accurately determined with reference to some fixed datum. It is used to start or to check a line of levels. It should be located so as to be easily found, accessible, permanent in character and permit the rod to be held vertically on it without difficulty.

A T. P. is an intermediate point whose elevation is determined in order to carry ahead a line of levels.

53. Explain or illustrate the various ways in which Bench Marks are fixed on engineering works.

Bench marks are fixed on:—

1. Copings of walls, such as area walls, retaining walls, abutment walls, &c.

2. Water tables, sills, steps, column bases or pedestals that are set on firm foundations.

3. On exposed roots of trees or on telegraph poles not apt to be disturbed.

4. On catch basin heads and fire hydrants, &c.

5. On exposed ledge rock, monuments, &c.

In 1 and 2 square or circular cuts usually indicate the location of the B. M.

In 3 spikes are solidly driven and location and elevation indicated on blazed portion above B. M.

In 4 knobs or bolts and appropriate cuts mark the benches.

In all cases they must be easily accessible, afford unobstructed sights and be readily identified.

54. In giving "rod" for an accurate sight, describe everything you would do.

Select a good T. P. visible to the leveler, and convenient for the next set-up.

See that the point is rigid for the time being, that the rod rotates freely on it and that the point, and bottom of rod are free from foreign matter.

Hold the rod on the point, plumbing it by balancing it freely between the fingers; move the target up or down as directed by leveler, and upon proper signal clamp the target. Check setting, read carefully and record.

If the high rod is used set the target accurately on proper graduation and move the extension up or down, clamping at the proper signal.

Move the rod to and from the leveler following his instructions, until signal O. K. is given finally; then remove rod carefully from T. P. and read. Be sure that neither the target nor the rod has slipped. Record the reading and have rod checked.

55. How can you be reasonably sure that you are plumbing the rod correctly in both directions?

By holding the rod lightly between the fingers and observing that it balances itself when unsupported, also by moving the rod back and forth, setting the target to the smallest reading, and plumbing it as directed by leveler. Rod levels will enable one to plumb very closely.

56. State all the sources of error you may introduce as a rodman into your work through carelessness or neglect.

1. Selecting poor and unstable T. P.'s.
2. Holding the rod on the wrong point.
3. Not holding the rod plumb.
4. Permitting foreign matter to get under the rod.
5. By setting the target wrong on a long rod.
6. By letting the rod or target slip after setting.
7. By reading the wrong end of vernier or in wrong direction.

57. State how carelessness in manipulation, when extending the rod, may introduce error.

In using an extended or long rod errors may be introduced by—

Not having the target set properly on starting.

By slipping of the target before it is set by the leveler.

Slipping of the rod before reading it, due to careless clamping.

By not holding the rod plumb.

By incorrect reading of the vernier.

58. How can you expedite the work of a leveler and make it more accurate by care in the location of turning points?

(Other forms of same question.) State what things must be attended to in locating a turning point to the best advantage for correct and accurate work?

In locating a T. P. for leveling, what should guide the rodman?

In locating turning points the following points should be considered:

They should be visible to the leveler.

They should be convenient for the next set-up of the level.

They should be about the right height (not too low nor too high).

The distance from the instrument should not be too great (150 to 300 ft. in good work).

The foresight should be equal to the last backsight if possible.

The points should be firm and not easily disturbed.

They must permit the rod to be held vertically and freely rotated on them.

59. In careful work where you have not been instructed specifically, how far would you think it safe to go from the leveler in giving a foresight?

From 150 to 300 ft., depending on conditions of the atmosphere.

60. Is the rodman called in any way to assist in the prevention of mistakes in the record of sights at turning points, and, if so, state how in full?

Yes. The rodman should keep a separate set of notes showing readings on all T. P.'s and B. M.'s as a check on the leveler. He should compute the elevations and frequently compare them with the leveler. He should have the readings checked before changing the rod.

61. What notes should a rodman keep?

He should keep notes of the readings on all T. P.'s and B. M.'s, their location and description, and the computed elevations.

62. State all difficulties a rodman has to contend against in trying to do good work in the city.

The main difficulties a rodman encounters in the city arise from the interference due to traffic, obstructions to the line of sight, and projections from buildings.

These render the selection of suitable turning points more difficult than in open country.

63. Is it always necessary to read the rod to thousandths? If not, state when less careful readings may be taken.

On the T. P.'s and B. M.'s in accurate work the rod should be read to thousandths.

In running profiles, cross sections, contours, etc., where B. M.'s have been already established along the line, it is sufficient to read to 100ths on T. P.'s, and only to 10ths on center line, side or other stakes.

64. Does a rod held out of plumb make the rod reading on a point too great or too small? How may this fact be made use of in plumbing a rod?

Holding the rod out of plumb makes the rod reading too great.

By taking the shortest reading on the rod as it is swayed to and from the instrument the leveler, the error in plumbing is eliminated.

65. Suppose the rod to be extended to 10 ft., figure how much out of plumb must it be to make an error of one-thousandth in the reading?

The correct rod reading being 10.000 ft. the actual reading would be 10.001 ft., the distance out of plumb is thus equal to

$$\sqrt{10.001^2 - 10.000^2} = \sqrt{.020001} = 0.141' = 1.69''$$

66. A target set on a rod at 5.00 is 0.3 ft. out of plumb. How much difference will it make in the elevation read as compared with the correct elevation?

The actual rod reading being 5.00 ft. and the distance out of plumb 0.3 ft., the correct reading will be

$$\sqrt{5.000^2 - 0.30^2} = \sqrt{24.910} = 4.991'$$

67. Suppose you are asked to set up a level, state every point to be observed.

In setting up a level the following points must be considered:

1. Condition of the instrument:

a. The instrument should be firmly secured to the tripod.

b. The tripod and leveling screws should be snug.

c. The clamp should be loose so that the head swings freely.

2. Location of the instrument:

a. The sights should be unobstructed.

b. The instrument should be set in solid ground and as far as practicable from sources of disturbance.

c. The sights should be of a length determined by the character of the work and conditions of the atmosphere.

3. Setting up the instrument:

a. A rough sight should be taken on rod to observe that the line of sight does not strike below the bottom or above the top.

b. The tripod legs must be set firmly in the ground.

c. The head approximately level.

d. One set of leveling screws about on line with the general direction of the work.

e. Instrument is then leveled accurately.

68. Describe minutely everything requiring attention in the proper setting up of an engineer's transit in case you are called upon to do it.

In setting up a transit the following points must be observed:

The head should be firmly secured to the tripod.

The tripod and leveling screws should be snug.

The alidade clamp must be loose so that the head swings freely.

The legs must be set firmly in the ground, the head being at a convenient height for sighting.

The plate should be approximately level and the plumb bob should swing very close to but not rest on the point, so that it can be brought exactly over it by means of the shifting head.

One pair of leveling screws should be set on line, the plate leveled roughly, and the head moved until bob is accurately over point, when plate is accurately leveled. The transit is then ready for sighting.

69. Having a series of backsights and foresights starting from a bench mark, of known elevation, state how you would use them to obtain elevation of last point.

First find the sum of all the backsights and the sum of all the foresights. Then take the difference between sum of the backsights and the sum of foresights. If the former is greater *add this difference* to the elevation of the bench mark.

If the sum of the foresights is the greater, *subtract this difference* from elevation of the bench mark to get the elevation of the last point.

70. What are curvature and refraction, and what relation do they bear to each other?

As the earth is a spheroid points on the surface are not in the same horizontal place. The amount of departure from this plane is termed the "curvature."

Refraction is the apparent raising of an object produced by the bending of the rays of light in passing from the object to the eye (through layers of air of varying densities).

Curvature causes an object to appear too low while refraction makes it appear too high. The correction for the former is therefore to be added to and for the latter to be subtracted from the observed elevation. The correction for refraction is equal to about 1/7 of that for curature, being 8 in. per mile for the latter and 1.1 in. per mile for the former. For other distances the corrections for both curvature and refraction vary as the squares, being 4 times as much for 2 miles, 9 times as much for 3 miles, etc.

71. What can a rodman do in his work to eliminate the effects of curvature and refraction?

He should select T. P.'s so that foresights and backsights will be equal. Wherever the sights are necessarily unequal he should endeavor to compensate in selecting succeeding turning points.

72. The distances between sights on a bench run are as follows: B. S., 450 ft.; F. S., 200 ft.; B. S., 600 ft.; F. S., 300 ft.; B. S., 150 ft.; F. S., 300 ft.; B. S., 150 ft.; F. S., 300 ft.; B. S., 50 ft.; F. S., 300 ft. Will there be any error from curvature? Give your reasons?

No; there will not be any error, because the sum of the backsights (450 + 600 + 150 + 150 + 50 = 1 400) in this case is equal to the sum of the foresights (200 + 300 + 300 + 300 + 300 = 1 400).

The errors due to curvature as well as those due to refraction and adjustments are the same in amount for both the fore and the backsights, but plus in one case and minus in the other. They, therefore. balance each other.

73. Are sights ever taken between regular stations; if so, what are they called and how located?

Yes; they are called "Intermediates."

In running profiles intermediate sights are taken:

1. Where there is a prominent change of slope in the surface of the ground.

2. Where there is a change of grade.

3. Where the center or side grade meets the natural surface.

4. At angle points, at beginning and end of curves and at end of lines.

They are located by plus distances from the preceding full station.

74. In railroad or aqueduct work, how are stakes or stations usually marked or numbered—how are intermediate distances marked?

Stations are usually set at every 100 ft. from the starting point and marked

1 + 00 2 + 00 3 + 00, etc.

Where there is a change of slope or of grade and where the finished grade meets the natural surface, intermediate stakes are set and marked with the preceding station and the plus distance from it. Thus 5 + 25, 6 + 35, etc.

75. Describe the sights used in running transit lines for backsights.

Plumb bobs either held or fixed.

Steel or wooden rods 6 to 10 ft. long, each foot painted alternately with contrasting colors.

Sharp pencil point, tacks, pins, etc.

Sighting boards having well defined center lines.

76. Why is it not desirable to have the line of sight run too close to the ground in many cases?

If the line runs too close to the ground, the sight may be often obstructed by grass-weeds, stones, etc. It will also be affected to a greater extent by radiation or "air tremor," causing "dancing" of the rod and target.

77. In what way does the sun, wind, frost, ice, snow, etc., affect leveling?

The sun causes shortening of bubbles, unequal expansion in different parts of instrument, "air tremor" or "dancing" of rod, and "glare" of target.

The wind makes it difficult to plumb the rod, and causes vibration of instrument.

Frost, ice and snow render stable ste-ups more difficult where the level is set upon ice, snow or frosty ground, settlement will occur when the temperature rises. Bench marks are liable to change in elevation when set on objects which do not extend below frost line.

78. What are contour lines? How are they obtained?

A contour is a continuous line passing through points on the surface of the ground of equal elevation. It may also be defined as the line of intersection of a level surface with the earth's surface. The water edge of a pond or lake is an example.

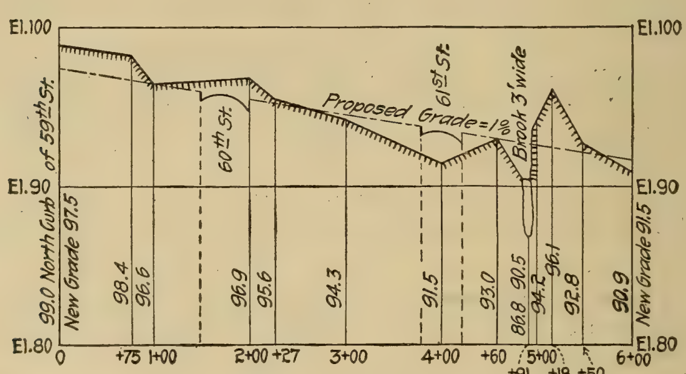
79. What is a profile and how constructed? What levels should be taken in the field in order to show the profile?

A profile is a drawing showing the irregularities of the surface of the ground along a given line.

Levels should be taken at regular stations, also at all changes of slope of the ground.

To construct the profile, draw a horizontal line to represent the assumed datum plane. On this lay off to scale the stations at which elevations have been taken and plot the elevations at these points to any desirable scale. The line joining the latter points will be the profile desired.

The vertical scale is usually magnified so that the "breaks" in the surface of the ground will appear more prominent to the eye.



Profile on Center Line of Proposed Street.

80. (*a*) What is a cross-section?

(*b*) In taking a cross-section, for grading a new street, how many sights are usually taken and where?

(*a*) A cross-section is a profile showing the breaks in surface of ground, at right angles to center line of the road. The grade line at the station at which the section is taken and the slope lines are also drawn to show the amount of cut or fill.

(*b*) In cross-sectioning for new street sights should be taken at center line, curb lines and house lines; at breaks in the surface, and at intersections of slopes with the surface of the ground.

81. Explain two methods of setting slope stakes.

1. Plot cross-sections of road on cross-section paper and plot the grade and slope lines at the respective stations. The intersection of the slopes and natural surface show at once the distances of the slope stakes from the center line. These may be tabulated and the stakes set accordingly.

2. Compute the cut or fill at the side or "shoulder" of the road.

Obtain by trial with the level rod points on the surface such that their distance from the side stake will equal the slope × their height above or below grade. The slope stakes are set at these points.

82. Are the vertical and horizontal scales in a profile the same? If not why are they made in different scales?

Horizontal and vertical scales are usually not the same in profile.

The vertical irregularities of the surface are usually small compared with the length of line and the vertical scale is made larger, so that these changes in elevation will appear more prominent to the eye.

83. Can you keep level notes? If so, fill out blank sheet showing headings of columns as you have been in the habit of keeping them and place therein figures enough to show your method.

LEFT-HAND PAGE OF FIELD BOOK. RIGHT-HAND PAGE OF FIELD BOOK.

Date..........................

Party { .... / .... / .... / .... / ....

(Title and location of work).

Sta.	B. S.	H. I.	F. S.	Elev.	Rem.	
B. M. No. 25	(See p. 24)			33.241		
	2.250	35.491				
T. P.			3.251	32.240		Top of Hydrant, S W. Cor. 8th and Fulton Sts.
1+00			4.2	31.3		
2+00			5.3	30.8		
3+00			3.2	32.3		
4+00			3.6	31.9		
4+25			3.6	31.9		Centre Line, Jackson Ave
5+00			7.1	28.4		
T. P.			6.235	29.156		Spike in Tel. Pole No. 324.
	0.301	29.457				
5+00	(Check)		1.1	28.4		
+50			3.2	26.7		
+60			4.1	25.4		
6+00			3.8	25.7		
7+00			5.6	24.9		
B. M. No. 30	(See p. 26)		3.927	25.530	Diff.	
				(25.536)	.006	

84. How is the velocity of flow of a stream measured?

Velocity of flow is measured by current meters and by floats. The current meter is lowered into the stream and the revolutions of its wheel, recorded on a graduated dial, give the velocity of flow. When floats are used the time elapsed in moving a known distance down steam gives the velocity.

85. How many parts of a plane triangle must be given to find the rest?

Three parts must be given, of which one must be a side.

86. What are similar triangles?

Triangles that are equi-angular or whose corresponding sides are proportional.

87. (*a*) What is the difference between an inch and a tenth? (*b*) What between a sq. yd. and 3 sq. ft.?

(*a*) One-tenth = 1.2 in. The difference between 0.1 ft. and 1 in. is therefore 0.2 in., or, .01$\frac{2}{3}$ ft.

(*b*) 1 sq. yd. = 9 sq. ft. Difference is therefore 9—3 = 6 sq. ft.

88. What portion of an inch is .001 of a foot?

.012 of an inch.

89. Can you calculate cubical contents in earthwork? How do you do it?

Plot cross-sections of road and the grade and slope lines, preferably on cross-section paper.

Find area of each cross-section either by means of planimeter, counting squares or by computation.

Average successive areas and multiply by respective distances between them.

Add the partial products or volumes thus obtained, for the total volume. If the computations have been made in feet, which is usually the case, divide the total volume by 27 to obtain the volume in cubic yards.

90. A cubic foot of water contains how many gallons? Weighs how much?

A cubic foot of water contains 7.48 gallons, and weighs 62.5 lbs.

91. Suppose a piece of ground to have the sides parallel but of unequal length (in other words trapezoidal in form), how would you measure it and compute the area?

To compute the area it is only necessary to measure the lengths of the parallel sides and the shortest or perpendicular distance (altitude) between them. The area $= \frac{1}{2}$ sum of parallel sides $\times$ altitude.

But practically all four sides and the two diagonals should be measured. The area of the trapezoid can then be calculated from the known sides of the triangles. This will give a good check on the previous calculation. If a, b, c, are the sides of a triangle, and s, half their sum, area of triangle

$$= \sqrt{s\,(s - a)\,(s - b)\,(s - c)}.$$

Mathematics.

What is the difference between the square of $\frac{1}{2}$ of 32 and $\frac{1}{2}$ the square of 32? (b) Extract the square root of $25.0\frac{3}{4}$, correct to 4 places of decimals.

(a) The square of $\frac{1}{2}$ of $32 = (\frac{1}{2} \times 32)^2 = 16^2 = 256$.

$\frac{1}{2}$ the square of $32 = \frac{1}{2} \times 32^2 = \frac{1}{2} \times 1\,024 = 512$.

Difference $= 512 - 256 = 256$.

(*b*) $25.0\frac{3}{4} = 25.075$.

$$
\begin{array}{rl}
 & 25.0750 \quad (5.0074 + = \sqrt{25.0\frac{3}{4}} \\
 & 25 \\
 & \overline{} \\
10007) & .075000 \\
 & 70049 \\
 & \overline{} \\
100144) & 495100 \\
 & 400576 \\
 & \overline{} \\
 & 94524
\end{array}
$$

93. The perimeter of a rectangular field is 140 rods; from one corner to the center of the field is 25 rods, find dimensions and area.

Since perimeter = 140 rods, $\frac{1}{2}$ perimeter = 70 rods.

Since distance from center to center = 25 rods, diagonal = 50 rods.

Let $x =$ number of rods in one side of rectangle,
then $70 - x =$ number of rods in other side of rectangle.

$$x^2 + (70 - x)^2 = 50^2$$
$$x^2 + (4\,900 - 140\,x + x^2) = 2\,500$$
$$2\,x^2 - 140\,x = 2\,500 - 4\,900 = -2\,400$$
$$x^2 - 70\,x = -1\,200$$

Completing square,

$$x^2 - 70\,x + 35^2 = 35^2 - 1\,200 = 1\,225 - 1\,200 = 25$$
$$(x - 35)^2 = 25$$
$$x - 35 = \pm 5$$
$$x = 35 \pm 5 = 30 \text{ or } 40$$

Sides are therefore 30 and 40 rods, respectively.

Area $= 30 \times 40 = 1\,200$ square rods $= 7\frac{1}{2}$ acres.

94. On opposite sides of a stream 40 ft. wide stand 2 trees, 83 ft. and 57 ft. in height; what is the distance between the tops of the trees?

The difference in elevation between the tops of the trees = $83 - 57 = 26$ ft. The perpendicular distance between trees = 40 ft.

We thus have a right-angled triangle the base of which is 40 ft. and altitude 26. The hypothenuse, which is the distance between the tops of the trees is therefore

$$\sqrt{40^2 + 26^2} = \sqrt{1\,600 + 676} = \sqrt{2\,276} = 47.7 + \text{ ft.}$$

95. A city lot cost \$2 250 at \$0.40 a sq. ft., the parallel sides were 39 ft. and 51 ft. respectively; what was the length of the lot?

The area of the lot was $= 2\,250 \div 0.40 = 5\,625$ sq. ft.

$$\begin{aligned} \text{Area} = 5\,625 &= \tfrac{1}{2} \text{ sum of parallel sides} \times \text{length} \\ &= \tfrac{1}{2}(39 + 51) \times \text{length} \\ &= 45 \times \text{length}. \end{aligned}$$

Therefore length $= \frac{5625}{45} = 125$ ft.

96. A cylindrical column of granite is 13.09 ft. in circumference and its volume is 818.125 cu. ft. What is the height of the column?

Let h = the height of the column and r the base.

The circumference $= 2\pi r = 2 \times 3.1416\, r = 13.09$ ft.

$$r = \frac{13.09}{2 \times 3.1416}$$

The area of the base $= \pi r^2 = 3.1416 \times \left(\frac{13.09}{2 \times 3.1416}\right)^2$

$$= \frac{(13.09)^2}{4 \times 3.1416}$$

The height of the column $= \dfrac{\text{Volume}}{\text{Area of Base}}$

$$= 818.125 \div \frac{(13.09)^2}{4 \times 3.1416} = 818.125 \times \frac{4 \times 3.1416}{(13.09)^2} = 60 \text{ ft.}$$

97. A street a quarter of a mile long has on each side a sidewalk $7\frac{1}{2}$ ft. wide; what will it cost to pave this sidewalk (both sides) with stones each 2 ft. 9 in. long by 1 ft. 8 in. wide and costing 75c?

The length of each sidewalk $= \frac{1}{4} \times 5\,280 = 1\,320$ ft.

Area of paving required for both sidewalks

$$= 2 \times 1\,320 \times 7\tfrac{1}{2} = 19\,800 \text{ sq. ft.}$$

Area of each paving stone

$$= 2\tfrac{3}{4} \times 1\tfrac{2}{3} = \tfrac{11}{4} \times \tfrac{5}{3} = \tfrac{55}{12}$$

Number of stones required $= 19\,800 \div \frac{55}{12}$

The cost of each stone being 75c.,

the entire cost of the paving $= 19\,800 \div \frac{55}{12} \times .75$

$$= 19\,800 \times \tfrac{12}{55} \times \tfrac{3}{4} = \$3\,240.$$

98. Two vessels sail at the same time from the same place, one sailing due east and the other due north at the rate of 6 miles and 8 miles an hour, respectively. How far apart will they be at the end of 12 hours?

At the end of 12 hours, one vessel will have sailed $12 \times 6 = 72$ miles east and the other $12 \times 8 = 96$ miles north.

As they sail at right angles the distance between them at the end of 12 hours

$$= \sqrt{72^2 + 96^2} = \sqrt{5\,184 + 9\,216} = \sqrt{14\,400} = 120 \text{ miles.}$$

How many square yards in a graveled walk 6 feet wide, running around a circular fish pond whose diameter is 70 yards?

The radius of the pond $= \frac{1}{2}$ of $70 = 35$ yards.

" " of the outside of the walk $= 35 + 2 = 37$ yards.

The area of walk = total area to outside perimeter of walk — area of pond

$$= \pi \times 37^2 - \pi \times 35^2 = \pi \times (37^2 - 35^2) = 144\,\pi$$
$$= 144 \times 3.1416 = 452.39 \text{ sq. yds.}$$

100. A piece of property 500 ft. wide is to be divided into 5 lots of unequal width. Beginning at the narrowest, each is to be 5 ft. wider than the one before it. Find the width of the lots.

Let x = number of feet in width of narrowest lot.
Then $x + 5$ = " " " " 2d lot.
$x + 10$ = " " " " 3d "
$x + 15$ = " " " " 4th "
$x + 20$ = " " " " 5th "

$5x + 50$ = total number of feet in width of plot = 500.

$x + 10 = 100.$

$x = 100 - 10 = 90$ = width of narrowest lot.

The width of lots are therefore 90 ft., 95 ft., 100 ft., 105 ft. and 110 ft.

101. What is the contents in cubic yards of retaining wall which has one face vertical and is 123 ft. long. One end is 18 ft. high, base 10 ft., top 2 ft. and the other end is 12 ft. 6 in. high, base 7 ft. 6 in., top 2 ft. (The prismoidal formula may be used, but is not required.)

Let A_1 = area at one end.
A_2 = " " other end.
A_m = " of section midway between.
D = distance between ends = 123 ft.

By prismoidal formula :

$$\text{Volume} = (A_1 + A_2 + 4\,A_m) \times \frac{D}{6}.$$

By average end area method :

$$\text{Volume} = (A_1 + A_2) \times \frac{D}{2}.$$

$$A_1 = 18 \times \frac{2 + 10}{2} = 108.$$

$$A_2 = 12.5 \times \frac{2 + 7.5}{2} = 59.37.$$

$$A_m = \frac{18 + 12.5}{2} \times \frac{2 + \frac{10 + 7.5}{2}}{2} = 15.25 \times 5.37 = 81.97.$$

By prismoidal formula:

$$\text{Vol.} = (108 + 59.37 + 4 \times 81.97) \times \tfrac{123}{6} = 495.25 \times \tfrac{41}{2}$$
$$= 10\,152.62 \text{ cu. ft.} = 376.0 \text{ cu. yd.}$$

By average end area method:

$$\text{Vol.} = \frac{108 + 59.37}{2} \times 123 = 10\,293.5 \text{ cu. ft.} = 381.2 \text{ cu. yd.}$$

102. A pipe 4 ft. inside diameter, running full, discharges into a canal 5 ft. wide with vertical sides; how deep will the water be in the canal?

The depth of water will be such that the area of the wetted canal section will equal the inside area of the pipe.

$$\text{Area of pipe} = \frac{\pi\, d^2}{4} = \frac{\pi}{4} \times 4^2 = 4 \times 3.1416 = 12.5664 \text{ sq. ft.}$$

Since the canal is 5 ft. wide and its sectional area must be 12.5664 sq. ft., the depth of water will be

$$\frac{12.5664}{5.0} = 2.51+ \text{ ft.}$$

MANUAL OF EXAMINATIONS

FOR

ENGINEERING POSITIONS

IN THE

SERVICE OF THE CITY OF NEW YORK

QUESTIONS AND ANSWERS

IN 3 VOLUMES

VOL. I. AXEMAN, CHAINMAN AND RODMAN, LEVELER, AND TRANSITMAN AND COMPUTER

VOL. II. ASSISTANT ENGINEER

VOL. III. DRAFTSMAN AND INSPECTOR

VOL. I. PART III.

LEVELER

INDEX

NEW YORK

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1906

PREFACE.

In the "Previous Examination Papers" which have been included in this book, the questions may not, in all cases, be identical in wording with those actually given at the examinations, as copies of the original papers are not readily procurable, but they do embody the substance of the questions asked.

In the section devoted to "Typical Questions and Answers," the answers indicate in a general way only what is required of the candidate, and are not intended to be perfect and complete, as reasonable variance of opinion may exist as to what is the best answer in many cases, owing to differences in interpretation of the question and in education and experience.

In order to perpetuate the value of this book, blank leaves have been inserted after the "Previous Examination Papers," allowing for the convenient addition of new sets, and the "Typical Questions and Answers" have been interleaved, to provide space for notes, sketches and additions.

PREVIOUS EXAMINATION PAPERS.

LEVELER.

Salary, $1,200-$1,500 per annum.

Technical.

1. State, in their proper order, without describing them, the several adjustments of an engineer's level.

2. State generally what are the two methods of adjusting the bubble to parallelism with the line of sight.

3. (*a*) Describe the "peg" method of making this adjustment.
(*b*) Which is the most exact method of making this adjustment, and why?

4. (*a*) Is it possible to do correct work with an instrument out of adjustment?
(*b*) If so, explain how it is that errors are eliminated.

5. (*a*) In very exact or "precise" leveling, what would be the limit of length of sight you would take?
(*b*) Explain why you would adopt this limit.

6. Describe the proper method of adjusting for "parallax" when using a level.

7. (*a*) What are the causes of parallax?
(*b*) How would they affect the adjustments?

8. (*a*) An instrument being in perfect adjustment, does it sight a truly level line to a distant point, or does it require correction? If so, state how.
(*b*) Describe the errors, if any.

9. (*a*) What is the law of increase of effect due to curvature?
(*b*) Assuming eight inches in a mile, how much would it be in 500 feet?

10. How do cold and frost tend to cause errors in leveling?

11. How does heat cause errors in leveling?

12. How may sunlight cause trouble?

13. Under what conditions or times of day are these troubles the least?

14. What other difficulties or causes of error are there in leveling in a crowded city?

15. Give a form of record of levels on a long street and explain the terms used.

Mathematics.

1. Divide 27 and 2 tenths by 10 and 625 thousandths.

2. Extract the square root of .00390625.

3. The two ends of a floor are 19 feet and 16 feet long. One side, perpendicular to the ends, is 28 feet long. Find the area of the floor and the length of the fourth side.

4. Find the solid contents of the frustum of a cone whose altitude is 18 feet, diameters of bases being 8 feet and 6 feet.

Experience.

1. What is your age?

2. (*a*) Have you studied in any technical school or college? If so, how long, and when did you graduate?
(*b*) What other engineering instruction have you had?

3. Have you served as rodman? If so, how long, and on what work?

4. What experience have you had as leveler? Give dates and places where work was done.

LEVELER.

Technical.

1. Describe briefly an engineer's level.

2. State the adjustments of the level in their proper order.

3. What causes are liable to alter the correctness of a level after it has been correctly set up?

4. How would you locate rod and level to avoid these?

5. What is the last thing a leveler should do before taking a sight?

6. What instructions would you give your rodman for doing accurate work?

7. Give form of notes showing grade, cut, and fill for ten stations and construct profile for same.

8. Take any two centre cuts and construct cross-section profiles at their stations, slopes $1\frac{1}{2}$ to 1; show your notes.

9. What are contour lines? How constructed?

10. What is a fair error to allow for one mile of leveling?

11. How would you construct permanent bench marks in a city and how check them?

12. Give classification of excavation and fill generally used in regulating and grading streets.

13. Give estimate of monthly work done, in regulating and grading streets, previous estimates having been given.

14. What is refraction? Does it increase or decrease error due to curvature of the earth?

15. What is error due to curvature for one mile? Give proportion for increase for more than one mile.

16. What are the duties of a leveler?

17. How would you get an approximate difference of elevation of two banks of a river 2 000 ft. wide without considering curvature of the earth?

18. Calculate by prismoidal formula the contents of a road section 100 ft. long of which the following are the end sections, slopes $1\frac{1}{2}$ to 1:

Mathematics.

1. Calculate the capacity of tank, in gallons, whose upper diameter is 10 ft., lower diameter 14 ft., and height 8 ft.

2. Extract square root of 913.132754.

3. Divide 0.003172 by 3.1724.

4. Calculate volume of prismoid 30 ft. $\times$ 4 ft. $\times$ 100 ft. high.

5. Calculate volume of wedge with same dimensions as preceding question.

6. Given a retaining wall whose height is 20 ft., batter on front face $1\frac{1}{2}$ in. per foot, offsets on rear face 6 in. in every 5 ft., width of top 2 ft., length 50 ft. Find contents in cu. yds.

PROMOTION EXAMINATION LEVELER.

1. (*a*) What is your age? (*b*) Have you had any technical education at an engineering school or elsewhere, and, if so, what? (*c*) What practical experience have you had to fit you for the position of leveler? State this clearly and give dates.

2. Describe carefully the adjustments of an engineer's level in their proper order.

3. (*a*) What would be the longest sight you would think it desirable to take in doing very careful work? (*b*) Give your reasons for so limiting the length.

4. (*a*) How far does the line sighted by a level depart from a true level at the end of the first mile; or, in other words, what is the amount of the earth's curvature for a mile? (*b*) Does curvature make a point sighted on appear too high or too low?

5. (*a*) Describe what is meant by refraction. (*b*) Which of the two has the greater effect upon the correctness of levels, curvature or refraction?

6. In practice how are errors from curvature and refraction eliminated?

7. (*a*) What is parallax? (*b*) How may it cause errors in leveling?

8. (*a*) In leveling up or adjusting an instrument, how should all screws be left as to tightness? (*b*) What is the reason for this?

9. (*a*) What considerations govern the selection of a point at which to set up a level, in taking a line of levels? Describe carefully the setting up in the best way.

10. What natural causes may affect the accuracy of levels and must therefore be guarded against?

11. In taking a careful sight, state every precaution to be observed from beginning to end to insure accuracy.

12. What errors may be caused by carelessness or inexperience of a rodman?

13. If obliged to set your level on marshy or unstable ground, how can you get good results?

14. Divide 17.0965 by 209.07.

15. Extract the square root of 46027.009.

PROMOTION EXAMINATION LEVELER—PRES. BORO. B'KLYN.

Nov. 2, 1905.

1-3. Demonstrate your ability to write a clear, concise statement and your fitness for promotion by a suitable statement of your age, education and experience.

4. Assume a line of levels with the following distances between the T. P.'s: B. S. 150 ft., F. S., 250 ft.; B. S. 200 ft., F. S., 300 ft.; B. S. 600 ft, F. S. 250 ft.; B. S. 150 ft., F. S. 200 ft.; B. S. 100 ft., F. S. 200 ft. Is the correctness of the last elevation affected? Give reasons

5. Explain fully how the grade of a brick sewer is given by a leveler and how given by the foreman.

6. What is parallax? What causes it and how is it avoided?

7. What is radiation and how is its influence minimized?

8. Describe the method of setting slope stakes.

9. What instructions would you give your rodman to insure proper holding of the rod, setting of target and accurate reading?

10. Assume you had to use transit with bubble tube on telescope for leveling; how would you adjust it so it could be used for leveling?

11. If the combined effect of curvature and refraction is 229 ft. in 20 miles, what is it in 10 miles? (Show calculations.)

12. Show level notes for the centre line of a highway over irregular ground for a distance of 1 500 ft., including crossing a stream and intersecting another highway.

13. Draw a profile of 700 feet of the line in Ques. No. 12 to approximate scale showing grade line and other usual information.

14. (*a*) Find area of a right-angled triangle of which base is 43 ft. and hypothenuse is 67 ft.

(*b*) Find area of triangle of which sides are 20 ft., 30 ft., and 40 ft.

15. Explain clearly "reciprocal" leveling.

PROMOTION EXAMINATION TO LEVELER.

MAY, 1904.

1. (*a*) What is your age? (*b*) Your education? (*c*) Experience?

2. (*a*) What is the line of collimation? (*b*) What is the adjustment for the line of collimation?

3. What other adjustment (if any) is made for the crosshair?

4. (*a*) Give an adjustment necessary for the bubble on the Engineer's level. (*b*) Do you consider this the best method; why?

5. What other adjustment is there for the bubble?

6. (*a*) When the level is adjusted, is it safe to trust the accuracy of the instrument for a long time? (*b*) How may the length of sights be chosen to eliminate errors? Explain fully.

7. What precautions should be taken to prevent the rod and target from slipping?

8. What precaution should a leveler take to guard against the rodman misunderstanding his signals?

9. (*a*) What do you understand by curvature and refraction? (*b*) How will they influence the rod readings in a sight of x feet? (*c*) Which is the greater and what is their ratio?

10. After setting up the level, what disturbing influences are liable to affect it? How should the leveler guard against them?

11. How does the leveler know if the rodman holds the rod plumb?

12. (*a*) Why is it not good to take long sights in accurate leveling? (*b*) What do you consider the limits in such work?

13, 14 and 15. Figure the material to be excavated in a road section 100 ft. long, the ends having the dimensions given in sketch, slope of the embankment being $1\frac{1}{2}$ horizontal to 1 vertical.

LEVELER.

DEC. 22, 1904.

TECHNICAL.

1. (*a*) What is parallax in a level? (*b*) What are the two causes of parallax and how are they overcome?

2. Describe the adjustment of the line of collimation on an engineer's level.

3. (*a*) Describe the method of adjusting the bubble on an engineer's level by reversion. (*b*) What instrumental imperfection may make this method inaccurate?

4. Describe a method of adjusting on an engineer's level by use of the pegs.

5. Can a bubble be correctly adjusted by the peg method before the line of collimation is adjusted? Give your reasons.

6. (*a*) In very accurate leveling what would be the longest sight you would think it best to take? (*b*) Give two or more reasons for this.

7. Aside from the apparent "dancing" of the target caused by radiation of the heat from the earth, state in what other ways the sun affects the work of the leveler.

8. State clearly what errors in leveling are eliminated by keeping the lengths of the backsights and foresights equal.

9. Describe the operation of carrying a line of levels across a deep stream, says 1 500 feet wide, with reasonable accuracy.

10. (*a*) Where a roadway is to have slopes on each side of one and a half horizontal to one vertical, the cuts on the centre line stakes being given, describe the operation of setting slope stakes for the contractor. (*b*) Show the form of the notes you would keep as you lay out the work.

11. In what distance does the error in elevation of the target due to curvature of the earth amount to .001 of a foot? Give figures of the computation.

12. Suppose the leveler to have taken an accurate sight of the target, what may happen to cause a wrong elevation of the target to be recorded?

13. Give all the reasons for sighting the target again after giving the signal all right to the rodman.

14. (*a*) How do you fix the grades for a sewer? (*b*) What is the greatest distance that should exist between grade marks where the grade is very flat? Why is this?

15. In an extensive rock cutting how would the work be laid out, and how would the quantities for a monthly estimate of the work done be obtained?

Give an example of notes taken in the case of a deep rock cut 700 ft. by 80 ft. for a street.

Mathematics.

Give all the figuring on ruled sheets.

1. A lot of ground is 97 ft. 4.5 inches long and 24 ft. $7\frac{5}{8}$ inches wide. How many square feet are there in the lot? Do all the work by decimals.

2. The rise of a street in a distance of 5 763 ft. is 12.967 ft. What is the percentage of the grade?

3. The section across the embankment made in building a road is as follows: Width at top or road bed, 40 ft.; slopes of embankment at each side, one and a half horizontal to one vertical. Left hand slope stake 10 ft. below roadbed; left hand angle point or beginning of slope, $8\frac{1}{2}$ ft. below; centre point 8 ft. below; right angle point $9\frac{1}{4}$ feet below; right slope stake $8\frac{3}{4}$ ft. below. What is the area of the section? Make a sketch and give all figures.

4. The original surface of a road is a rapid rise, being uniform, and the surface of the cross sections are level and slopes $1\frac{1}{2}$ to 1. Cut at one end is 3 ft.; width at bottom 40 ft. and at top 49 ft. At the other end the cut is 7 ft. with width at bottom of 40 ft. and top 61 ft. The length between the sections is 100 ft. Compute by the prismoidal formula the contents in cubic yards.

MANUAL OF EXAMINATIONS

FOR

ENGINEERING POSITIONS

IN THE

SERVICE OF THE CITY OF NEW YORK.

LEVELER.

TYPICAL QUESTIONS AND ANSWERS.

LEVELER.

TYPICAL QUESTIONS AND ANSWERS.

1. What are the duties and requirements of a leveler?

A leveler is required to run the level, take charge of the party and direct the work for levels, profiles, contours, cross-sections, grades on construction, etc. He should keep notes of same in a neat and legible manner, and should do rapid and accurate work.

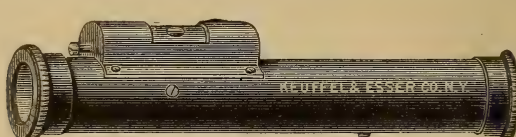
He should see that the instruments are kept in good condition and in proper adjustment. He should thoroughly understand the principles of leveling, be familiar with all sources of error and avoid them as much as possible. He should be able to use logarithms, trigonometric functions, compute elevations, cuts, fills, grades, earthwork quantities, etc.

He is expected to take the place of the transitman in the latter's absence.

2. For what different purposes are engineers' levels used?

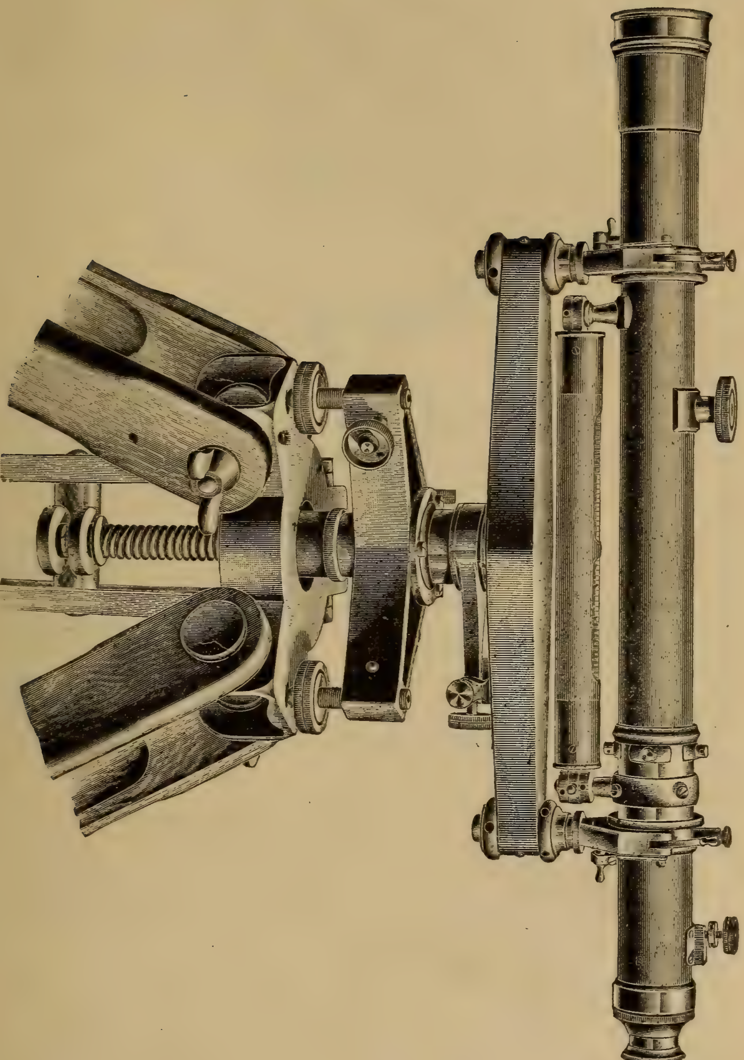
They are used for running levels and establishing bench marks, obtaining profiles, grades, contours, cross sections, setting grade and slope stakes, and giving elevations on construction.

3. What kind of level would you use for rough, rapid work?
A Locke or hand level.



4. What kind of level for accurate work? Describe it briefly.

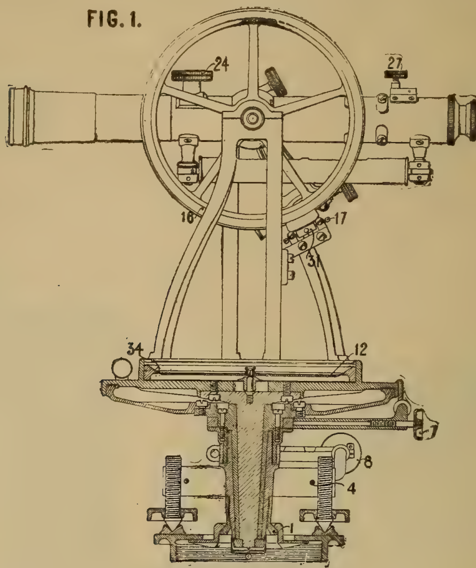
For accurate work use an engineer's level. An engineer's or "Y" level consists of a horizontal telescopic line of sight attached to a spirit level, and revolving about a vertical axis, the whole being properly supported and mounted on a tripod. The telescope can be lifted out of its supports, called the Y's, and reversed end for end. Leveling screws are provided to bring the bubble to the centre, and clamps and tangent motions to set and keep the telescope in a fixed position. Adjusting screws are provided for the cross-hairs, bubble tube and the Y's.



ENGINEER'S LEVEL.

5. Describe the engineer's transit and name the adjustments.

FIG. 1.



ENGINEER'S TRANSIT.

The transit is a telescopic line of sight which may be revolved in vertical and horizontal planes about axes provided for the purpose, the whole properly supported and mounted on a tripod. The angular movement of the line of sight is indicated on graduated horizontal and vertical limbs. By means of leveling screws, the axes are brought to their proper positions. Clamp and tangent screws to set and hold the line of sight in any position are provided, as well as adjusting screws for the various parts. The adjustments which are usually made are:

Adjustment for parallax.

To make plate bubbles perpendicular to the vertical axis of the instrument.

To make the line of sight perpendicular to the horizontal axis.

To make the horizontal axis perpendicular to the vertical axis.

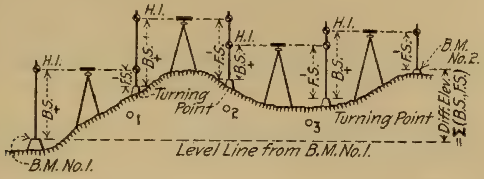
To make the axis of the attached bubble tube parallel to the line of collimation (for leveling).

6. Explain distinctly and briefly the operation of leveling.

The object of leveling is to obtain elevations of points referred to some known or assumed datum. This is attained by using an instrument (called a level), whose line of sight revolves in a horizontal plane, the elevation of which is called the height of instrument or H. I. Readings are taken on a graduated rod held ver-

tically on the points. These readings show the vertical distance of the bottom of the rod above or below the height of the instrument.

The H. I. is obtained by adding the rod reading (called the backsight or B. S.), taken on a point to the known elevation of the point. The elevation of any point is obtained by subtracting the rod reading (called the foresight or F. S.) taken upon it, from the H. I.



7. (*a*) What is the line of collimation? (*b*) What is the adjustment for the line of collimation?

(*a*) The line of collimation is the true position of the line of sight. It is the line joining the intersection of the cross-hairs (when in perfect adjustment) and the principal point of the objective.

(*b*) For adjustment of line of collimation see Q. No. 15.

8. What do you understand by parallax in taking a sight, and how is it overcome?

Parallax is the apparent motion of the cross-hairs about the image of the object sighted at, as the eye is moved behind the eye-piece, and is due to lack of coincidence of cross-hairs and image. It is overcome by focusing the eye-piece on the cross-hairs so that they appear most distinct, and by bringing the image into focus by means of the objective.

9. Name two causes of parallax.

1. Imperfect focusing of eye-piece on the cross-hairs.
2. Imperfect focusing of objective on the object sighted at. See also Q. No. 8.

10. Describe the proper method of adjusting for parallax when using a level.

Throw objective out of focus or direct telescope to the sky. Move eye-piece in and out, finding limits for distinct vision of cross-hairs, and set it at mean position. Then bring image into focus by means of the objective. Test adjustment by shifting the eye behind the eye-piece, observing whether there is any apparent movement of cross-hairs about the image.

11. (*a*) Is a first-class level in perfect adjustment? (*b*) What causes tend to throw a level out of adjustment?

(*a*) No, not in *perfect* adjustment. It may or may not be in sufficiently good adjustment for use.

(*b*) The adjustments are "thrown out" by jarring, improper or careless handling, temperature changes, wear, strain and looseness of adjusting screws, etc.

12. How do you tell when a level is out of adjustment? Are special trials necessary, and when should they be made?

The condition of the adjustment of the level can usually be told and tested during the course of the work. If the bar or bubble tube is out of adjustment the bubble will not remain in centre as telescope is revolved. If elevations are taken on two points, first with equal sights and then with very unequal sights, any appreciable error in the adjustments will become apparent.

It is advisable to test the adjustments on starting a level run, and where great accuracy is required they should be specially tested at least once a week. In ordinary work *special* trials are not necessary, as the leveler can usually tell by the behavior of the instrument when it requires adjustment.

13. State in order of their importance the adjustments of the engineer's level.

1. Adjustment for Parallax.*
2. Adjustment of Cross-Hairs.—To make the line of sight coincide with the axis of the telescope, so that the intersection of the hairs will remain on a fixed point as the telescope is revolved in the Y's.
3. Adjustment of the Attached Level.—To make the axis of the level tube parallel to the line of sight, so that the bubble will remain in centre when telescope is reversed end for end in the Y's.
4. Adjustment of the Y's or Telescope Supports.—To make the axis of the pivot rings revolve in a horizontal plane, so that the bubble will remain in the centre in all positions of the telescope.

14. How would you make them? Describe briefly.

For the "Parallax" adjustment see Question No. 10.

For the "Collimation" adjustment see Question No. 15.

For the "Bubble" adjustment see Question { No. 17. { Reversal method. / No. 18. { Peg method. }

For the "Y" adjustment see Question No. 21.

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* While Parallax is termed an adjustment, it is not one in the sense of the others.

15. How would you adjust the line of collimation?

Set up level about 20 ft. from a building or other stationary object. Level up and sight on a fixed point. Clamp instrument and open clips. Rotate telescope in Y's, observing whether intersection of cross-hairs remains on point. If not, observe the extreme movement of the wires and bring them half way back. Test the adjustment and repeat if necessary.

NOTE.—In the inverting instrument the intersection of cross-hairs must be moved in a direction opposite to the apparent.

16. State the two methods of adjusting the bubble to parallelism with "line of sight."

1. Adjust bubble by reversing the telescope in the Ys.
2. By the peg method.

17. (*a*) Describe reversal method of adjusting bubbles. (*b*) What other test should be made to secure parallelism of the bubble to the line of sight?

(*a*) Set instrument in shady place free from wind and other disturbances. Level up. Bring telescope parallel to one set of screws and clamp. Open clips. Lift telescope carefully out of Y's; reverse end to end and replace gently in Y's. Observe if bubble remains in centre. If not, correct half by the leveling screws and half by adjusting screws on bubble tube. Repeat adjustment if necessary.

(*b*) The bubble should also be tested to see that its axis and the line of sight are in the same vertical plane. This is effected by opening clips, turning telescope slightly in Y's and observing whether bubble remains in centre. If it does not it can be adjusted by means of the screws on the sides of the bubble tube.

18. Describe the peg method of adjusting the bubble in detail.

Set up instrument on fairly level ground. Drive two stakes firmly about two hundred ft. on either side of instrument, setting their tops at the same elevation. As the B. S. and F. S. are equal, the errors of adjustment are eliminated. Now set the instrument about 10 to 15 ft. beyond one of the points and about on line with them. Set the target, holding the rod on near point; then with target unchanged hold on far point. Bring cross-hairs on target by means of the leveling screws and bring the bubble to the centre by means of the adjusting screws. The bubble axis is then parallel to the line of sight. Test the adjustment by checking the elevation of the stake.

19. Which is the most exact way and why?

The peg method is the most exact, as the bubble is adjusted to an accurately established horizontal line, whereas in the reversal method it is assumed that the axis of pivot rings and telescope are parallel; which may or may not be true.

20. Can the bubble be correctly adjusted by the peg method before the line of collimation is adjusted? Give your reasons.

The bubble can be adjusted to the line of sight by the peg method and correct results obtained, but the line of sight must not then be distrubed, as its parallelism with the bubble axis will thus be destroyed. This parallelism is the object of the peg method.

21. If the bubble does not remain in the centre as the telescope is revolved, what adjustment is necessary and how is it made?

The Y or horizontal bar adjustment must be made. Level up the instrument. Bring the telescope parallel to one set of leveling screws; reverse telescope 180° about vertical axis. Observe the amount of movement of the bubble from the centre. Correct one-half by means of the leveling screws and the other by means of the adjusting screws on the Y's or bar. Test and repeat if necessary.

22. In leveling up or adjusting an instrument how should all screws be left as to tightness? What is the reason for this?

The screws should be left snug, but not tight enough to bind or spring the parts. They must be snug to prevent movement affecting the accuracy of the work. If made too tight the parts are liable to excessive wear and injury.

23. Is it possible to do correct work with an instrument out of adjustment? If so, explain how.

Yes. By taking equal back and foresights errors are eliminated. (See Q. No. 50.)

24. State clearly what errors in leveling are eliminated by keeping backsights and foresights equal.

The following errors are eliminated:

Errors due to imperfect adjustments.
" " " curvature of the earth.
" " " refraction.

25. How would you locate permanent bench marks in a city and how would you check them?

Permanent bench marks should be located at accessible points on stable foundations, where they are likely to remain undisturbed for a considerable period of time, such as—on water tables, area copings or stone steps, etc., of permanent buildings. They should be indicated by suitable marks cut in the stone in places where the rod can be freely rotated and held vertically without interference from projections. They should be carefully described, a sketch showing the exact location supplementing the description where necessary. They are checked by running accurate lines of levels from other established bench marks to the new bench. These runs or circuits are combined and adjusted and the resulting elevations of the new B. M. averaged.

26. In the operation of leveling how are the sights or readings taken on B. M.'s and T. P.'s designated, and how used in determining difference in level?

Sights on B. M.'s and T. P.'s are called backsights and foresights.

A backsight is a rod reading taken on a point whose elevation is known. This reading when added to the known elevation gives the H. I.

A foresight is a rod reading taken on a point whose elevation is to be determined. This reading when subtracted from the H. I. gives the desired elevation.

27. Describe all the steps in the field work of taking a line of levels over difficult ground, in such a way as to eliminate as far as possible errors of every nature and for every cause whatever.

It is best to select a time when atmospheric conditions are favorable, such as calm, cloudy day. Test the adjustments of the level. Set up in firm ground, within 250 ft. from starting point. Level up. Take a very careful rod reading (backsight) on the bench, the rod being held perfectly plumb on the point. Signal the rodman to set and clamp the target. Check the setting. The rodman then removes the rod carefully from the point, reads it, and records the reading, and proceeds to the leveler, who checks the rod. The rodman then selects and holds the rod on a T. P. not apt to be disturbed between the two set-ups, and at about the same distance from the instrument as the B. M. This T. P. may be a point on natural rock or top of pin driven into the ground for the purpose, or other suitable point. Take a rod reading (foresight) on this new point, check, read and record as before. Move the level ahead, check the "rod," and set up in advance of T. P. at a distance determined by the topography (not exceeding 300 feet, however, for accurate work), and proceed as before.

To eliminate all errors, observe following precautions:

That there is no instrumental parallax.
That the instrument is in good adjustment.
That the instrument does not settle.
That the bubble is in center at setting of target.
That the instrument is free from disturbing influences, such as sun, wind and jar, etc.
That the rodman holds on the right points.
That turning points are good and firm.
That the rod is held plumb and when extended target properly set, the shortest reading being taken.

28. What considerations govern the selection of a point at which to set up a level in taking a line of levels? Describe carefully the setting up in the best way.

The selection of the point is governed by the direction in which the work is progressing (whether up or down hill), the slope and character of the ground, obstructions to the line of sight, condition of the atmosphere, degree of accuracy of the work required, nature of the work, number of elevations to be taken from the set-up.

Select a point from which the T. P. is visible and about the right height, convenient for the next set-up, and which will afford the desired number of unobstructed sights. Set the legs firmly in the ground, the head being approximately level and bring one pair of leveling screws on line with the backsight. Observe if instrument is at proper height. If so, level up accurately.

29. If obliged to set your level on unstable or marshy ground, how can you get good results?

Set the legs as deep in the ground as convenience for sighting will permit, and surround them with heavy stones or stakes until they are firm, or set them on plank or board firmly imbedded in ground. Lest the instrument be disturbed, there should be as little moving about by the observer as possible. The bubble should be carefully watched, and before and after a turning point is set ahead check readings should be taken on the backsight.

30. Will two persons who take the same reading of a transit after setting it always make it the same; if not, why?

No. Because no two persons have the same power of observation. This is usually referred to as the "personal equation" of the observer.

This may cause a difference in bisecting the point sighted on, in setting the vernier on zero, in reading the angles, etc.

31. State all the precautions a leveler must take in doing accurate work.

He should supervise the selection of turning points and observe that the rodman holds, reads and handles the rod properly. He should have rod readings on T. P.'s checked and frequently check on points of known elevation. He should keep the instruments in good adjustment and see that it is properly handled in carrying, etc. In setting the target he should be sure that the rod is plumb, the target clamped, the bubble in the centre, before he signals the final O. K. He must always set his instruments up firmly, avoid wind and sun as much as possible. He must be sure of his starting B. M., keep the rod readings in the proper columns and have the rodman keep separate notes of the rod readings on the T. P.'s as a check upon his work.

32. Under what conditions and times are the atmospheric errors least?

Atmospheric errors are least on a cloudy day, when the air is clear and quiet. The best time of day for leveling is between 9-11 and 2-4, at which times disturbances due to the sun and refraction are least.

33. How do cold and frost tend to produce errors in leveling?

If the instrument is set up on frosty ground settlement occurs when the ground thaws, making it difficult to do accurate work.

34. What difficulties and errors are there in leveling in a crowded city?

Constant vibration of instrument due to traffic. Interference with line of sight by traffic, pedestrians and obstructions.

Danger of instrument being run into, obscure light, dust, etc., rendering long sights impossible.

It is more difficult to secure firm set-ups on stone pavements of crowded city than in open country.

35. What is radiation, and how is its effect minimized?

Radiation is the apparent vibration or "dancing" of the rod caused by currents of heated air which rise from the surface of the ground. The effect is minimized by taking the readings as high on the rod as possible and doing the work between the hours of 10 P. M. and 4 P. M., or on cloudy days, at which times these disturbances are the least.

36. (*a*) What should a leveler always do before setting up? (*b*) What before finally leveling up? (*c*) What before signalling O. K. finally?

(*a*) Before setting up he should look about and select the most favorable location. (See Question No. 28.)

(*b*) He should observe that he is neither too high nor too low.

(*c*) He should see that the bubble is in centre.

37. What is the last thing the leveler should do before taking a sight?

Observe that the bubble is in the centre.

38. What instructions would you give your rodman to insure proper holding of the rod setting the target and accurate reading?

The rodman should be instructed—

To be sure of his T. P.

To hold the rod as steadily and as "plumb" as possible, balancing it between his fingers or observing rod levels.

To be sure that the turning point and bottom of the rod are clean and that there is no interference by limbs or obstructions.

To watch the leveler, move the target up or down as directed, and clamp snugly at the proper signal.

For very accurate work, to hold again on the point, sway the rod to and from the instrument and, if necessary, to move the target carefully as directed and clamp at the proper signal.

To repeat this operation until finally signalled O. K.

To remove the rod carefully from the point, read it and record the reading, give the leveler another sight to make sure that the target has not slipped, and then to have the reading checked.

In the case of a long rod, to be sure that the target is properly set, that it does not slip, to have the setting checked after reading and then have the target and reading checked.

39. Suppose you had set target accurately, why should you again check sight? What errors are likely to occur in setting target?

The target and the rod, if extended, are both liable to slip. It is therefore necessary to check it after clamping.

If the instrument is provided with three wires a common error is made by setting the target on the wrong wire.

The rod may not be held plumb or the bubble may not be exactly in the centre. There may be parallax and air tremor. In all these cases errors may arise in setting the target.

40. What precaution should a leveler take to guard against the rodman misunderstanding his signals?

He should take a check reading after each setting of the target, and have the rodman sway the rod to and from the instrument, to obtain the smallest reading.

41. How does the leveler know if the rodman holds the rod plumb?

By means of vertical cross-hair the leveler can tell whether rod is plumb in one direction. To be sure that rod is plumb in the other he has the rod swayed gently to and from the instrument, and notes the smallest reading.

42. (*a*) In locating a T. P. for leveling upon, what should guide the rodman?

The rodman should be guided by the direction in which the work is progressing. He must see that the rod will be visible to the leveler, solid, and permit a good set-up when the level is carried ahead. In leveling down hill he should select the point as low as possible, and in working up hill he should select it as high as possible, consistent with proper lengths of sights. The rod must rotate freely on the point. If possible he should select his T. P.'s so that the fore and back sights will be equal.

43. Aside from the position of a turning point, is there any care necessary as to its stability, form, etc.? State in detail.

A turning point should be firm, solid and not likely to be disturbed between the two set-ups of the instrument. They should be pointed or rounded, so that the rod can rotate freely on them.

44. What is the difference between "refraction" and "reflection" as applied to light, and how does the former affect the line of sight taken through a level? Discuss the combined effect of curvature and refraction in leveling.

"Refraction" is the *bending* or *deflection* which rays of light experience in passing through media of varying densities, such as from air to water, or through layers of air of varying temperature and humidity.

"Reflection" is the *rebound* which rays of light experience on striking any surface; when the surface is polished the rebound or reflection is most pronounced and follows regular laws.

In sighting through a level, refraction (due to the atmosphere) causes an apparent *raising* of the rod, making it appear higher than

it really is. The correction is therefore *minus*. The amount varies with the temperature and humidity of the atmosphere, winds, time of day and distance of rod from level. It is greatest after sunrise and before sunset and least between 10 A. M. and 4 P. M. As an average, the error due to refraction is 1/7 of the error due to curvature of earth's surface, reducing the latter from 8 in. in one mile to 6.86 in. in one mile. It is, therefore, about 1.14 inches in 1 mile.

The increase in the error, both for "curvature" and "refraction," is, as the *square* of the distance, being 4 times as much as 2 miles, 9 times as much for 3 miles, etc.

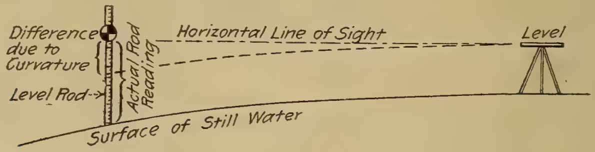
That is

Correction for curvature
(to be added) = 8 inches × (Dist. in Miles)^2.

Correction for refraction
(to be subtracted) = 1.14 " × (" " ")^2.

Combined correction for
both (to be added) = 6.86 " × (" " ")^2.

In running levels with unequal back and fore sights the correction is to be added to the final elevation when sum of the foresights (distances) exceeds the sum of the backsights (distances), and subtracted when the sum of the backsights is in excess. The distance for which the correction is to be applied is always the difference between the above sums.



45. (*a*) What is refraction when referred to leveling?
(*b*) Does it increase or decrease error due to curvature of earth?
(*c*) What is the error due to curvature in one mile?

(*a*) Refraction is the apparent raising of the rod due to bending of the rays of light coming from the rod to the instrument. See Question 44.

(*b*) It decreases the error due to curvature by 1/7 of the latter.

(*c*) The error due to curvature is 8 in. in 1 mile and is proportional to the square of the distance.

46. An instrument in perfect adjustment, does it sight a truly level line to a distant object, or does it require correction; if so, how? Describe the errors, if any.

The instrument sights a *horizontal*, and not a *level*, line. It requires correction for curvature of the earth and refraction due to the atmosphere by adding eight inches in one mile for the former

and subtracting 1 1/7 inches for the latter. The curvature causes a larger rod reading, while refraction causes a smaller.

For other distances the corrections vary as the squares of the distances.

47. What is the law of increase of effect due to curvature? How much in 500 ft.?

Error due to curvature is 8 in. in 1 mile, and increases as the square of the distance in miles.

For 500 ft. curvature correction $= 8'' \times \left(\frac{500}{5280}\right)^2 = .\quad ''.$

$$= 8'' \times .009 = 0.072''.$$

$$= .006 \text{ of a foot.}$$

48. If the combined effect of curvature and refraction is 229 ft. in 20 miles, what is it in 10 miles? (Show calculation.)

The error due to curvature and refraction varies as the square of the distance; therefore:

Error in 10 miles : error 20 miles : : $10^2 : 20^2$

$$x : 229' :: 100 : 400$$

$$x = \frac{229 \times 100}{400} = 57.25'$$

49. Assume a line of levels with the following distances between the T. P.'s:

B. S. 150 ft., F. S. 250 ft.; B. S. 200 ft., F. S. 300; B. S. 600, F. S. 250; B. S. 150; F. S. 200; B. S. 100; F. S. 200.

Is the correctness of the last elevation affected? Give reasons.

The elevation of the last point will *not* be affected, because the sum of the backsight distances (150 ft. + 200 + 600 + 150 + 100 =1 200) is equal to the sum of the foresight distances (250 + 300 + 250 + 200 +200 = 1 200 ft.). The total error due to imperfect adjustments and to curvature and refraction will thus be the same for the foresights and for the backsights, but of opposite sign, and will therefore balance.

50. At what distance is the error in curvature = .001 ft.?

At 1 mile or 5 280 ft. error = 8 in. or 0.67 ft. The error varies as square of distance. Hence the required distance x is found from the equation:

$$\frac{x^2}{5280^2} = \frac{.001}{0.670}$$

$$x^2 = \frac{5280^2 \times .001}{0.67} = 41610'; \ x = 204' \pm.$$

51. What are the minimum and maximum lengths of sights you would take, and why, for fairly accurate work?

(*a*) For fair work sights from 15 to 600 may be taken. The instrument cannot be focused at less than 10 ft. and at 600 ft. the signals of leveler become indistinct to the rodman and the setting of the target doubtful.

52. For very exact work or precise leveling, what would be the limit of length of sight you would take? Why?

300 ft., except under special conditions, such as in crossing a river; because at a greater distance the target cannot be set accurately to thousandths; slight variations in the bubble produce considerable errors in long sights. The longer the sight the more liability to error due to atmospheric conditions.

53. Explain clearly what is meant by "reciprocal" leveling.

"Reciprocal" leveling is the operation of finding the difference in elevation between points a considerable distance apart, where for any reason the territory between is inaccessible, rendering the ordinary method impracticable. It is resorted to where it is necessary to transfer levels across a wide river or ravine. The instrument is set alternately on both sides of the river and a number of readings taken on the two points whose difference in elevation is sought. These differences in elevation observed from both sides are combined and averaged. The method of procedure is more fully explained in the following question.

54. If you had to cross a river 1 500 feet wide, how would you do it to get accurate results?

Select a day when conditions are favorable for good work, such as a clear, calm and cloudy day, and take the observations when the disturbances due to radiation and refraction are least—from 9 to 11 A. M. or from 2 to 4 P. M.

Test the adjustments of the instrument and perfect them if necessary.

Provide two first-class New York rods fitted with special targets for long sights and alike in all respect.

Select or fix suitable bench marks on each side of the river.

Set up the level a short distance (15 ft.) behind one of the points and about on line with them, the rodmen meanwhile proceeding to give sights (one on each side of river).

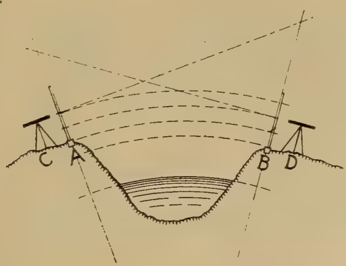
Level up carefully, take the observation on each rod, noting that the bubble is exactly in centre at the final sight, that the targets are

set on shortest readings, and taking other usual precautions for accurate work.

The readings are then recorded and checked and the operation repeated several times, obtaining a series of differences in elevation (which should closely check). These differences are averaged.

The instrument is then carried to opposite bank of river and operation repeated, obtaining a second set of differences in elevation.

Average the mean differences obtained from the two sets of observations and the result ought to give very closely the correct difference of elevation of the two bench marks, errors due to curvature, refraction being thereby eliminated as shown below.



Let A and B be two bench marks, one on each side of river. With level at C determine difference in elevation between A and B. Do the same with level at D, making $A\ C = B\ D$. Let E' and E'' be the absolute elevations of A and B, then

$d = E' - E''$, the true difference in elevation.

Let r_1 be the combined correction for curvature and refraction for $A\ D = C\ B$ and r_2 the correction for $A\ C = B\ D$.

The difference obtained by the instrument at C is

$$d' = (E' - r_1) - (E'' - r_2) \qquad (1)$$

With instrument at D, the difference is

$$d'' = (E' - r_2) - (E'' - r_1) \qquad (2)$$

Adding (1) and (2) and dividing by 2 we have

$$d = \frac{d' + d''}{2} = E' - E''$$

The corrections for curvature and refraction are thus eliminated by taking the average differences in elevation.

55. What errors would you expect in running a mile of B. M. levels (*a*) in a crowded street? (*b*) in the open?

(*a*) .04 in a mile.
(*b*) .02 in a mile.

56. What proportions for other distances?

Multiply the above errors by $\sqrt{\text{distance in miles}}$. Thus, for 4 miles it would be .04 $\sqrt{4}$, or .08.

57. In running profile, cross-section, or contour levels (*a*) how close would you expect to check on bench marks? (*b*) How close would you read on other stakes?

(*a*) Within a tenth.
(*b*) To the nearest tenth.

58. How close do you consider it necessary to read the rod on turning points (*a*) in good work? (*b*) in very accurate work?

(*a*) 100ths.
(*b*) 1000ths.

59. What is meant by the datum in leveling?

A datum is a level surface, assumed or actual, to which elevation of other points are referred.

60. What is a grade line?

A grade line is the line of intersection of a vertical plane (usually through the centre line) and the finished surface of a road, railroad, etc. It shows the rate of rise or fall and is usually expressed in feet per 100.

61. What are contour lines? How are they constructed?

Contour lines are lines passing through points on the surface of the earth, all of which are at the same elevation. A contour may also be defined as the line of intersection of a level surface with the earth's surface.

Three methods are commonly employed to locate contours.

1. By the Stadia.

The location and elevations of all high and low points, in the area to be mapped, tops of ridges, bottoms of hollows, and points at changes of slope, are obtained by means of the transit and stadia, and plotted on the map. The contours are then interpolated between the points thus plotted.

2. By the Plane Table.

The contours are followed on the ground by means of a level and rod, and the location of all points where there are changes in direc-

tion are plotted directly on the sheet. If the ground is too steep the contours may be interpolated between the controlling points plotted on the sheet.

3. By Cross-Sectioning.

The area to be mapped is "gridironed" or divided up into squares of convenient size (as 100 ft.). Elevations are taken at each corner and intermediates where there are changes of slope. These points are plotted and the contours then interpolated between them.

62. Suppose you have to set a very flat grade for a sewer, (*a*) how would you go about it? (*b*) How far apart would you set grade points? (*c*) Why?

(*a*) Establish bench marks along the line of work. On centre line, if possible, or on offset line, fasten cleats two or three ft. in length to the horizontal braces across trench. Upon the cleats marks are made, a given number of feet above the invert or flow line of sewer. A string stretched taut between the marks will give a line parallel to the sewer grade. When the trench is not sheeted the marks are placed on the side of the cut or upon convenient points, such as timbers thrown across.

(*b*) 20 ft. apart.

(*c*) The string stretched between points must have no sag.

63. Explain fully how the grade of a brick sewer is given by a leveler and how given by the foreman.

The leveler has cleats nailed to cross timbers on centre line of sewer, at suitable intervals, depending on the grade of the sewer. With the aid of level and rod, elevations of the tops of these cleats are obtained, and nicks are cut in them at a whole number of feet above the proposed flow line of the sewer. The distance above the flow line is marked on the cleats, as well as their station. The foreman measures down from a string stretched taut between these points with the aid of a stick of required length or a tape, and sets profiles or templets on line and grade.

64. Describe how you would "set out" the work for a job of street grading where there were both heavy fills and cuttings.

Run out centre line, setting stakes at half stations and at "breaks" in the slope of the ground and obtain profile of the line. Establish the grade line and compute cuts and fills along centre line. Take cross-sections at each station, setting side stakes at the specified distance, each side of centre line, and the slope stakes at points determined by trial. Upon the centre line stakes and the shoulder or side stakes the cuts or fills are plainly marked for the guidance of the contractor.

65. How would you set slope stakes for excavation and embankment for a contractor, having given the centre cut?

First Method.

Plot cross-sections of road showing grade lines and slopes on cross-section paper. The intersection of the slope and natural surface gives at once the distance from centre at which slope stakes should be set. Tabulate these distances and set the stakes accordingly.

Second Method.

Assuming a $1\frac{1}{2}$ to 1 slope, take elevation at side lines of road and compute cut or fill. By trial with the level and rod find a point on the ground whose height above or below grade equals $\frac{2}{3}$ its distance from the side. For a 1 to 1 slope the distance from the side equals the height and proportionately for other slopes. Set the slope stakes at points thus determined.

66. What are the usual slopes for embankments and excavation in rock, in earth?

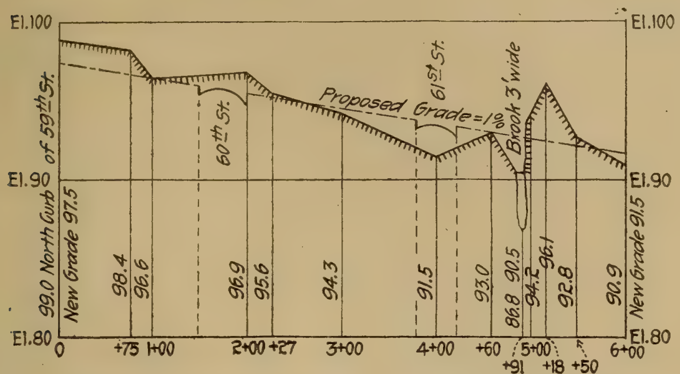
In excavation:
- Rock slope, $\frac{1}{4}$ to 1.
- Earth slope, $1\frac{1}{2}$ to 1 or 1 to 1.

In embankment:
- Rock 1 to 1.
- Earth, $1\frac{1}{2}$ to 1 or 1 to 1.

67. Take a full sheet and show various columns required for a set of levels, starting and ending at a B. M. Also insert a set of levels on a line at least 1 000 ft. long with intermediates for a brook crossing the topography.

Sta.	B. S.	H. I.	F. S.	Elev.	Remarks.
B. M. No.12	4.58	104.58	....	100.00	Spike in root of Elm tree, 50′ N.E. of road crossing.
10 + 00	....	....	3.4	101.2	
9 + 00	....	....	5.3	99.3	
8 + 00	....	....	7.6	97.0	
T. P.	7.82	101.82	10.58	94.00	Spike in tel. pole.
7 + 49	....	....	9.9	91.9	West shore line.
7 + 20	....	....	12.4	89.4	Bottom of brook.
6 + 98	....	....	10.0	91.8	East shore line.
6 + 00	....	....	3.6	98.2	
5 + 00	....	....	0.4	101.4	
T. P.	9.74	111.20	0.36	101.46	Projecting point of rock S. of R. R. track.
4 + 00	....	....	4.2	107.0	
3 + 00	....	....	3.4	107.8	
1 + 00	....	....	2.6	108.6	
0 + 00	....	....	1.7	109.5	
B. M. No. 11	....	....	1.32	109.88	El. 109.90 sq. cut S.E. cor. coping W. abutment B'dge. No. 56 N. Y. C. R R.

68. Draw a profile of 600 ft. of a proposed street to approximate scale, showing grade line and other usual information.



Profile on Center Line of Proposed Street.

69. Suppose you had to find the amount of excavation on deep cut for monthly estimate, how would you do it? Give set of notes.

At end of month take cross-sections of the bottom of excavation at same stations where the originals were taken and intermediates, if necessary. Plot the notes on original sheets. Compute areas of sections and from them figure volume of excavation. Subtract amount allowed in previous monthly estimate to obtain estimate for the month.

For set of notes see question No. 71.

70. In an extensive rock cutting, how would the work be laid out and how would the quantities for monthly estimate of the work done be obtained?

The work would be laid out as follows: Stakes would be set along centre line, side lines and along the slopes, with their respective cuts to subgrade plainly marked. Regular stakes should be 25 ft. apart, 12½ ft. on curves and intermediates at changes of slope or grade or line. Important stakes must be referenced, so they can be readily replaced if destroyed during the work.

The cross-section at each station is plotted, the grade and slope lines drawn, and the volume can then be computed. New cross-sections are taken each month at the same stations and others, if necessary, and plotted on the original sheets. The amount for the monthly estimate is obtained by deducting from the computed total the excavation allowed in the preceding months.

71. Give an example of monthly estimate notes taken for a street in the case of a deep rock cut 700 ft. by 80 ft.

Date..........

Monthly Est. No. 10.

Party. { ....
....
....

Road No. 20.

Sta.	B. S.	H. I.	F. S.	El.	Rem.	Cross-Sections.
	......	......	......	......	......	H. I. 59.2
7 + 00	......	......	......	......	......	....
	......	......	......	......	......	....
	......	......	......	......	......	....
	......	......	......	......	......	....
3 + 00	......	......	......	......	......	....
	......	......	......	......	......	o. s. $\frac{45}{4.1}$ $\frac{20}{3.2}$ $\frac{0}{5.0}$ $\frac{20}{3.1}$ $\frac{40}{3.5}$ o. s.
+ 75	......	......	......	......	......	
+ 50	......	......	......	......	......	
2 + 25	......	......	......	......	......	H. I. 52.3
	10.20	59.20	......	......	......	o. s. $\frac{35}{4.1}$ $\frac{20}{3.2}$ $\frac{0}{1.2}$ $\frac{5}{2.3}$ $\frac{20}{2.3}$ $\frac{40}{4.1}$ o. s.
T. P.	......	......	......	......	......	
2 + 00	......	......	3.27	49.00	......	48.2 49.1 51.1 etc.
+ 75	......	......	......	......	......	....
+ 60	......	......	......	......	......	....
+ 50	......	......	......	......	......	....
+ 25	......	......	......	......	......	....
+ 10	......	......	......	......	......	....
1 + 00	......	......	......	......	......	o. s. $\frac{30}{2.0}$ $\frac{20}{5.0}$ $\frac{0}{4.0}$ $\frac{20}{4.0}$ $\frac{40}{3.1}$ o. s.
+ 75	......	......	......	......	......	
+ 50	......	......	......	......	......	o. s. $\frac{30}{1.2}$ $\frac{20}{0.0}$ $\frac{5}{1.5}$ $\frac{0}{2.5}$ $\frac{10}{4.0}$ $\frac{20}{3.0}$
+ 25	......	......	......	......	......	
0 + 00	......	......	......	......	......	etc., etc.
	2.12	52.27	......	......	......	
B. M. No. 25	(See	p. 40.)	......	......	50.15	(o. s. = original surface.)

72. Give classification of excavation and fill generally used in regulating and grading streets.

Earth excavation, including loam, clay and boulders less than 1 cu. yd.

Loose rock, including rock which does not require blasting, and can be removed with pick, and boulders over 1 cu. yd.

Solid rock includes all rock which requires blasting for removal.

73. Give a form of monthly estimate for a contractor, previous estimate having been given.

TYPICAL FORM FOR MONTHLY ESTIMATE.—90 PER CENT. PAYMENT

THE CITY OF NEW YORK. ESTIMATE No........................

To.. ....Dr.

For work measured and estimated in constructing...................................., under a contract dated...from ....1. , to....................................1, .

Total Quantities Estimated to Date Including Present Estimates.	Total Quantities Previously Estimated.	Approximate Quantities Measured and Estimated for above Month.	Description of Work Done.			Unit Prices.	Monthly Amounts. Dollars.	Monthly Amounts. Cts.	Total Amounts. Dollars.	Total Amounts. Cts.
2 000	1 000	1 000		cubic yards	Removal of soil taken from spoil banks, including all work incidental thereto.	0.30	300	00	600	00
2 000	1 000	1 000	*aa*	square yards	Sodding, including all work incidental thereto.	0.20	200	00	400	00
2 000	1 000	1 000	*b*	cubic yards	Earth excavation, including the disposal of it, and all work incidental thereto.	0.30	300	00	600	00
2 000	1 000	1 000	*c*	cubic yards	Rock excavation, including the disposal of it, and all work incidental thereto.	2.00	2 000	00	4 000	00
2 000	1 000	1 000	*e*	M. ft. B. M.	Permanent timber work, placed and fastened, including all work incidental thereto.	55.00	55	00	110	00
2 000	1 000	1 000	*f*	barrels	Portland Cement, in barrels of 400 pounds, ordered by the Engineer, and placed in the work, including all work incidental thereto.	2.50	2 500	00	5 000	00
2 000	1 000	1 000	*g*	cubic yards	Concrete masonry in place, formed of five parts of broken stone, or gravel, or a mixture of both, to one part of cement, and made with American Cement Mortar mixed in the proportion of one part of cement to two parts of sand, including all work incidental thereto.	4.00	4 000	00	8 000	00
2 000	1 000	1 000	*h*	cubic yards	Brick masonry, not included in item (*h h*), laid in American Cement Mortar mixed in the proportion of one part of cement to two parts of sand, including all plastering and pointing, all scaffolding, centers, forms, etc., and removing the same, and all work incidental thereto.	9.00	9 000	00	18 000	00
2 000	1 000	1 000	*i*	cubic yards	Rubble stone masonry, laid in American Cement Mortar mixed in the proportion of one part cement to two parts of sand, including all work incidental thereto.	3.00	3 000	00	6 000	00
Total amount estimated									$42 700	00
Total amount previously estimated									21 355	00
Total amount of present estimate........................									$21 355	00
Total amount of work measured and estimated between the above dates....							$21 355	00		
Deduct 10 per cent..........................							2 135	50		
Balance due for work measured and estimated during the month..................							$19 219	50		

I hereby certify that this is a just estimate of the approximate amount of work measured and estimated between the............and........ days of ....190.. both inclusive.

CHIEF ENGINEER,

MATHEMATICS—LEVELER.

74. Given field 90 ft. $4\frac{7}{8}$ in. on one side, 21 ft. $4\frac{7}{8}$ in. on other. Find area.

$$\begin{aligned} \text{Area} &= 90'\,4\tfrac{7}{8}'' \times 21'\,4\tfrac{7}{8}'' \qquad (4\tfrac{7}{8}'' = \tfrac{39}{96}'' = .406'+) \\ &= 90'.406 \times 21'.406 \\ &= 1935.2 \text{ sq. ft.} \end{aligned}$$

```
      90.406
      21.406
     -------
      542436
     361624
     90406
   180812
  -----------
 1935.230836
```

75. Given rise of 12.547 ft. in distance 5763 ft., what is the grade?

$$\begin{aligned} 12.547 \text{ in } 5763 &= \frac{12.547}{57.63} \text{ in } 100' \\ &= .2177+ \% \text{ grade.} \end{aligned}$$

```
57.63)12.54700 ( .2177
      11.526
      ------
       1.0210
         5763
        -----
        44470
        40341
        -----
         41290
         40341
         -----
           949
```

76. Find area of a right-angled triangle of which base is 43 ft. and hypothenuse 67 ft.

$$\begin{aligned} \text{Area} &= \frac{\text{Base} \times \text{Altitude.}}{2} \\ \text{Base} &= 43. \\ \text{Altitude} &= \sqrt{67^2 - 43^2}. \\ \therefore \text{Area} &= \tfrac{1}{2} \times 43 \times \sqrt{67^2 - 43^2} \\ &= \tfrac{1}{2} \times 43 \times 51.4 = 1105.1 \text{ sq. ft.} \end{aligned}$$

77. Find area of triangle of which sides are 20′, 30′ and 40′.

$$\text{Area} = \sqrt{s(s-a)(s-b)(s-c)}$$

in which $s = \frac{1}{2}$ of $(a+b+c)$, a, b and c being the sides; that is.

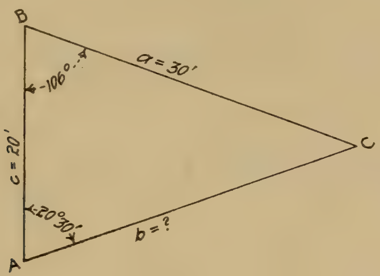
$$s = \tfrac{1}{2}(20+30+40) = 45.$$

$$\text{Hence area} = \sqrt{45(45-20)(45-30)(45-40)}$$

$$= \sqrt{45 \times 25 \times 15 \times 5} = \sqrt{84375}$$

$$= 290+ \text{ sq. ft.}$$

78. Find the side in the triangle and show your work.



$$\frac{a}{\sin. A} = \frac{b}{\sin. B}$$

$$\frac{30}{\sin. 20° \, 30'} = \frac{b}{\sin. 106°}$$

Whence

$$b = \frac{\sin. 106°}{\sin. 20° \, 30'} \times 30$$

$$\log. 30 = 1.47712$$

$$\left.\begin{array}{l}\log. \sin. \ 106° \\ \text{or } \log. \cos. \ 16°\end{array}\right\} = 9.98284$$

$$11.45996$$

$$\text{colog. sin. } 20° \, 30' = 0.45567$$

$$\log. b = 1.91563$$

$$b = 82.34+ \text{ Ans.}$$

79. The two ends of a floor are 19 and 16 ft. long. One side, perpendicular to the end, is 28 ft. long. Find area of the floor and the length of the fourth side.

$$\text{Area of floor} = \frac{19+16}{2} \times 28 = 35 \times 14 = 490 \text{ sq. ft.}$$

$$\text{Fourth side} = \sqrt{(19-16)^2 + 28^2} = \sqrt{3^2 + 28^2}$$

$$= \sqrt{9 + 784} = \sqrt{793} = 28.16 \text{ feet.}$$

80. Find the volume of a prism 30 ft. $\times$ 4 ft. $\times$ 100 ft. high.

$$\text{Volume} = \text{Area base} \times \text{height}.$$
$$= 30 \times 4 \times 100 = 12\,000 \text{ cu. ft.}$$

81. Calculate the volume of a wedge (same dimensions as in preceding problem) 30 ft. $\times$ 4 ft. $\times$ 100 ft. high.

$$\text{Volume of wedge} = \tfrac{1}{2} \text{ volume of prism}$$
$$= \frac{30 \times 4 \times 100}{2} = 6\,000 \text{ cu. ft.}$$

82. Find the solid contents of the frustum of a cone whose altitude is 18 ft., diameter of bases being 8 ft. and 6 ft.

$$\text{Volume} = \frac{1}{3} \text{ altitude} \times (\text{area upper base} + \text{area lower base} + \sqrt{\text{area upper base} \times \text{area lower base}}).$$
$$= \frac{1}{3} \times 18\,(\pi \times 4^2 + \pi \times 3^2 + \sqrt{\pi\, 4^2 \times \pi\, 3^2})$$
$$= 6\,\pi\,(16 + 9 + \sqrt{16 \times 9})$$
$$= 6\,\pi\,(25 + 12) = 222\,\pi = 697.44.$$

83. Compute the capacity in gallons of a tank—

whose upper diameter is 10 feet
lower " 14 "
and height 8 "
there being 231 cu. in. = 1 gal.

Prismoidal formula:

$$\text{Volume in cu. ft.} = \frac{l}{6}\left(\underset{\text{sq. ft.}}{\text{Top area}} + 4 \times \underset{\text{sq. ft.}}{\text{mid. area}} + \underset{\text{sq. ft.}}{\text{bottom area}}\right)$$

$1 = 8'$.

$$\text{Top area} = \pi \times 5^2$$
$$\text{Bottom area} = \pi \times 7^2$$
$$\text{Mid area} = \pi \times 6^2$$

$$\text{Vol.} = \frac{8}{6} \times (\pi\,.\,5^2 + 4\,\pi\,.\,6^2 + \pi\,.\,7^2)$$
$$= \frac{4\pi}{3}\left(5^2 + 4 \times 6^2 + 7^2\right)$$
$$= \frac{4\pi}{3}\left(25 + 144 + 49\right) = \frac{218}{3} \times 4\,\pi \text{ cu. ft.}$$

$\left(1\,728 \text{ cu. in. in 1 cu. ft., using } \pi = \frac{22}{7} \text{ and } 231 \text{ cu. in. in 1 gal.}\right)$

$$\text{Volume} = \frac{1728}{231} \times \frac{218}{3} \times 4 \times \frac{22}{7} = 6833.6 \text{ gallons.}$$

84. A retaining wall whose height is 20 ft., batter on front face $1\frac{1}{2}$ in. per ft., offsets on rear face 6 in. in every 5 ft., width of top 2 ft., length 50 ft. Required contents in cu. yds.

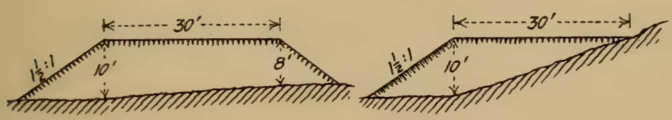
$$\text{Area cross-section} = \frac{2 + 4.5}{2} \times 20 + 30 \times 0.5 = 80.$$

$$\text{Vol.} = 80 \times 50 = 400 \text{ cu. ft.} = 14.8 \text{ cu. yds.}$$

85. Suppose the elevations of an invert of a sewer at 2 manholes were respectively 3.06 and 10.76, and distance 1 270 ft., what would be the grade as ordinarily given?

$$\frac{10.76 - 3.06}{1\ 270} = \frac{7.70}{1\ 270} = .00606 \text{ per foot} = .606\% \text{ grade.}$$

86. Calculate by prismoidal formula the contents of a road section 100 ft. long of which the following are the end sections, slopes $1\frac{1}{2}$ to 1.



$$\frac{8 + 10}{2} \times 30 + \frac{10 \times 15}{2} + \frac{8 \times 12}{2}$$

$$= 270 + 75 + 48 = 393 \ \square' = \text{area of 1st section} = A$$

$$\frac{45 \times 10}{2} = 225 \ \square' = \text{area of 2d section} = B$$

$$\frac{10 + 4}{2} \times 30 + \frac{10 \times 15}{2} + \frac{4 \times 6}{2}$$

$$= 210 + 75 + 12 = 297 \ \square' = \text{area of mid section} = M$$

Substitute in the prismoidal formula vol. $= \frac{l}{6}(A + 4M + B)$, the values from above, $l = 100$, $A = 393$, $B = 225$ and $M = 297$.

$$\text{Vol. in cu. ft.} = \frac{100}{6}\left(393 + 4 \times 297 + 225\right)$$

$$= \frac{100 \times 1\ 806}{6} = 30\ 100 \text{ cu. ft.} = 1\ 114.8+ \text{ cu. yds.}$$

87. Given street of uniform grade, with level sections 100 ft. apart, as follows: First section has 40 ft. bottom, 49 ft. top and

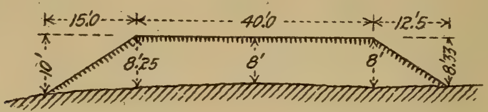
3 ft. cut; second section has 40 ft. bottom, 61 ft. top and 7 ft. cut.

$$\text{Vol.} = \left[\frac{49+40}{2}\times 3 + \frac{61+40}{2}\times 7 + 4\left(\frac{55+40}{2}\right)\times 5.0\right]\frac{100}{6}$$

$$= \left(\frac{267}{2}+\frac{707}{2}+\frac{1\,900}{2}\right)\times\frac{100}{6} = 23\,950 \text{ cu. ft.}$$

$$= 887\tfrac{1}{27} \text{ cu. yds.}$$

88. Given an embankment with roadway 40 ft., cut at centre 8 ft., at left angle stake $8\frac{1}{4}$, slope stake on left 10 ft. below roadway, cut at right angle stake 8 slope stake on right $8\frac{1}{3}$ ft. below roadway. Draw section and figure area.



Using $1\frac{1}{2}$ to 1 slope, slope stakes are set 15′ to left and 12′.5 to right.

$$\left(\frac{8.25+8}{2}+\frac{8+8}{2}\right)\times 20 + \frac{8\times 12.5}{2} + \frac{8.25\times 15}{2} =$$

$$\frac{32.25}{2}\times 20 + \frac{223.75}{2} = 322.5 + 111.87 = 434.37 \text{ sq. ft.}$$

MANUAL OF EXAMINATIONS

FOR

ENGINEERING POSITIONS

IN THE

SERVICE OF THE CITY OF NEW YORK

QUESTIONS AND ANSWERS
IN 3 VOLUMES.

Vol. I. AXEMAN, CHAINMAN and RODMAN, LEVELER and TRANSITMAN and COMPUTER.

Vol. II. ASSISTANT ENGINEER.

Vol. III. DRAUGHTSMAN, and INSPECTOR.

VOL. I. PART IV.
TRANSITMAN and COMPUTER.

INDEX

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NEW YORK

PREFACE.

In the "Previous Examination Papers" which have been included in this book, the questions may not, in all cases, be identical in wording with those actually given at the examinations, as copies of the original papers are not readily procurable, but they do embody the substance of the questions asked.

In the section devoted to "Typical Questions and Answers," the answers indicate in a general way only what is required of the candidate, and are not intended to be perfect and complete, as reasonable variance of opinion may exist as to what is the best answer in many cases, owing to differences in interpretation of the question and in education and experience.

In order to perpetuate the value of this book, blank leaves have been inserted after the "Previous Examination Papers," allowing for the convenient addition of new sets, and the "Typical Questions and Answers" have been interleaved, to provide space for notes, sketches and additions.

SPECIMEN EXAMINATION PAPERS.

TRANSITMAN AND COMPUTER

Technical.

Salary, $1 200-$1 800 per annum.

1. State the duties a transitman may be called upon to perform in the City of New York.

2. Describe a party organized for transit work and the duties of each person.

3. Where the best and most accurate work with a transit is required, describe every precaution requisite on the part of the transitman in adjusting, handling, protecting and sighting his instrument. (See also next question.)

4. How are errors in reading the instrument and in graduation of the limb guarded against or minimized?

5. (*a*) What causes are there for error in long sights? (*b*) Can these be guarded against in any way, and, if so, how?

6. Describe the operation of making an accurate survey of a city block, both exterior and interior, where every side is filled with buildings.

7. Give a sample of notes, as you would record them in your notebook, of a survey of a new street half a mile long, having several angles, and crossing other streets and a stream.

8. Describe the adjustment, for leveling purposes, of the long bubble which is attached to some transits.

9. Name all the other adjustments of a transit in the order in which they should be made.

10. Suppose you had to measure the distance between two objects on the opposite side of a stream without crossing it. (*a*) Describe the instrumental work necessary. (*b*) Make a sketch and describe the method of making the computation of the distance.

11 and 12. A trapezoidal piece of ground has one end at right angles to the parallel sides. The sides measure, respectively, 110 ft.

and 175 ft. and the inclined side has a length of 97 ft. Required first, to compute the perpendicular distance between the sides; and, second, to cut off $\frac{1}{3}$ of the area from the widest portion by a line parallel to the sides, computing its perpendicular distance from the widest side. (Show all figures.)

13. What is the limit of error allowed in chaining in measurements on city streets?

14. How can you compute a very small angle without the use of tables, having given the distance run and the side opposite the angle required?

15. An area of ground is to be used as a borrow pit. It has been laid out by lines at right angles to each other at suitable distances and the cuts at each intersection determined. How would you determine the cubical contents?

Arithmetic.

1. The inscribed circle in a regular octagon has a radius of 23 ft. What is the area of the figure?

2. Extract by logarithms the cube root of .0075218.

3. Multiply by logarithms 7.1263×0.0439.

4. The side of a right-angled triangle is 27 and the base is 13: (*a*) What is the natural sine of the angle opposite the base? (*b*) What is the natural tangent of the angle opposite the side? Note: Do this by arithmetic.

5. The radius of a circle is 50; what is the length of an arc of 28°? (Do this by arithmetic.)

Experience.

1. When and where were you born?

2. Have you taken a regular course of instruction as engineer in any college or technical school? If so, give the name and the length of the course; also state what degrees or diploma you received, if any.

3. If you have not taken such a course, state what education as an engineer you have had.

4. Have you followed any mechanical occupation? If so, what was it, and for how long?

5. State what experience you have had in the work of transitman or computer, particularly in city work.

6. State any other facts in your experience that you consider would help you as an engineer.

TRANSITMAN AND COMPUTER.

1. Explain what is meant by term refraction and in what way, if at all, it may affect line of sight of a transit instrument.

2. Does it make any difference what time of day a transit line is run, where accuracy is required, and, if so, under what conditions?

3. After setting up a transit before giving flagman a signal "all right," what should the instrumentman do?

4. In what ways may errors be made in reading an angle?

5. Will two persons taking the same reading of transit after setting always make it the same, and, if not, why not?

6. How is the effect of errors in graduation of the limb of a transit upon the accuracy of the work lessened by the method of use?

7. Suppose a random line to be run is measured, and it is found to end at one side of the point sought, by a small amount, what simple rule is there for determining the angular error by arithmetical proportion?

8. Compute the area of the following survey after making all necessary correction:

1	N 15° 15′ E	20	chains.	5	S 25° 45′ W	13.5	chains.
2	N 37° 30′ E	10	"	6	(missing)		
3	N 50° 0′ E	7.6	"	7	S 36° 30′ W	9.9	"
4	S 11° 30′ E	12.5	"	8	N 38° 15′ W	8.5	"

9. What is the difference between traverse tables and a table of natural sines and cosines?

10. How does a logarithm table differ from these and what advantage has it in use?

11. Give the complete organization of the party for making an important survey in the city.

12. Show two pages of your notebook on which are reported a line survey, having at least five courses, with road and brook crossings, offsets to barns and other buildings, and any other objects such as survey should take note of.

13. Suppose a survey is to be made, what other way or ways of examining it for errors are there besides that by latitudes and departures.

14. What are the sources of error in line measurement?

15. Suppose in making a survey in the city one or more lines are interfered with by buildings, how is the survey to be made?

TRANSITMAN AND COMPUTER.

1. Describe all the adjustments of an engineer's level in their proper order. State also what condition of the adjusting screws as to tightness will keep the instrument longest in adjustment and why?

2. Describe all the steps in the field work of taking a line of levels over difficult ground in such a way as to eliminate as far as possible errors of every nature and from every cause whatever.

3. Describe carefully all the adjustments of an engineer's transit in their proper order.

4. Describe carefully the operation of measuring a lot of irregular form where all measurements and lines of sight are taken from the interior.

5. Describe carefully the method of running a long straight line where several sights must be taken so as to avoid errors of every kind as far as possible.

6. State all the errors that may be made in reading the vernier of an instrument and how do you guard against them?

7. Give in best and neatest manner you can, a specimen of your level notes, showing at least ten stations on a line of considerable variation in level, with deduction of the same.

8. Give in same manner a specimen of your transit notes with enough stations to show how you would indicate a road and stream crossing, buildings, etc.

9. What shorthand method for use without tables is there for determining the correction angle for an offset to a point, where the distance run and offset are determined?

10. Describe carefully the operation of measuring an angle where greatest precision is necessary.

11. For the solution of a plane triangle, state the several problems that may arise, also what is the least number of sides that must be given.

12. Is there ever a case where two solutions are possible, and if so, what are the conditions?

13. What is a traverse table and upon what angular functions is it based?

14. What do you mean by a well-conditioned angle? Describe also its opposite.

15. Suppose that for any reason the measurements and angles for one side of an irregular lot are missing from a survey, and you wish to determine them, how would you do it?

TRANSITMAN AND COMPUTER.

1. (*a*) Describe the adjustment of the bubble on the limb of a transit. (*b*) How would the angles measured with the bubble out of adjustment be affected?

2. (*a*) Describe the adjustment of crosshairs. (*b*) Would the line of collimation being out of adjustment affect every angle measured? Explain this fully.

3. Suppose there is a vertical limb to an instrument, is any adjustment or test needed, and, if so, what?

4. Suppose the horizontal axis of the telescope to be not strictly at right angles to the vertical axis, how would it show itself in work done? And how would the adjustment of the instrument be made?

5. Describe all the causes of error in reading the limb of a transit.

6. Describe all the causes of error in the use of a transit, aside from errors due to instrument and of reading.

7. Give a sample of your notes in full, assumed without regard to balancing, for a survey of a large farm with at least 12 angles crossed by a stream and a railroad, containing farm buildings, etc.

8. State how you would arrange your party for such a survey.

9. Suppose obstructions on one of the sides to require that one angle be sighted to an offset stake; what is the form of the simple proportion by which you can determine the small angle required to correct the sight, requiring no tables for its use?

10. Give the form of a table required to balance such a survey as that in question. Explain its use.

11. Suppose you find the errors to be very considerable; is there any way by which you can determine where errors may probably be found? State what you would do.

12. In the use of a good transit of ordinary size, what would you expect the average error in each of a number of angles to amount to?

13. You are running the center line of a street, which at a given point turns (x) degrees to the right. The width of the street being (b) feet, give an algebraic expression for the distance to the angle stake which you must set at either side of the street.

14. A trapezoidal piece of ground is to be divided into two equal parts by a line parallel to the parallel sides. The parallel sides are, respectively, 575 and 437 ft. long. The other sides are 300 and 350

ft. long, respectively. State the distance to the dividing line from the longest parallel side on each of the other sides.

15. One of the sides of a hexagon is 30 ft.; what is the area of the hexagon?

Mathematics.

1. Divide by logarithms: .0007098 by 796.05.

2. The natural sine of 33° is .5446 and the natural cosine .8387. Determine by arithmetic the natural tangent.

3. Solve $\frac{x}{x \text{ plus } 1}$ minus $\frac{x \text{ plus } 3}{2\,(x \text{ plus } 4)}$ equals $\frac{1}{18}$.

4. Find the cubical contents of a solid wall of masonry 104 ft. 8 in. long, 12 ft. 3 in. high, 8 ft. broad on top and 10 ft. 4 in. broad at the bottom.

TRANSITMAN AND COMPUTER.

1. State as fully as you can the duties of a transitman.

2. Describe an engineer's transit and name the adjustments in the order in which they should be made.

3. State how a transit out of adjustment can be used to produce a straight line.

4. Describe the verniers upon a transit and state how you are enabled to read — to minutes — to half minutes.

5. What is a logarithm? In what calculations is a logarithm useful?

6. The diameter of end of a cylinder is 20, length 30, what are the cubical contents?

7. Define the terms, sine, cosine, tangent and co-tangent?

8. How many men are needed to make up a full party for the survey of a preliminary line or section of a public work, such as a railroad or aqueduct?

9. What are natural sines, cosines?

10. How many parts of a plane triangle must be given to find the rest?

11. Being required to run a straight line a mile in length, state what precautions you would take to secure accuracy in alignment.

12. Explain the operation of setting slope stakes.

13. Make an assumed cross-section of a canal in rock cutting, showing the levels taken at different dates during the progress of the work and compute the area removed by the contract at different dates assumed.

14. Draw the plan and elevation of a pyramid with a triangular base.

15. The radius of a curve is 600 ft.; find the degree of the curve.

16. Find the pressure per square inch at a depth of 100 ft. in a lake.

TRANSITMAN AND COMPUTER.

August 8, 1904.

Technical.

1. What is the very first adjustment of a transit that should always be made and how is it done?

2. (*a*) What planes should a transit instrument describe or revolve in truly, if in perfect adjustment? (*b*) In case it describes a cone when revolved on its horizontal axis, what adjustment must be made and how is it done?

3. If the plane described when revolved vertically is inclined to the vertical, what adjustment must be made and how is it done?

4. Describe fully the making of a topographical survey with a transit, and a stadia rod.

5. If an error of one minute be made in reading an angle, what would be the effect from the true line at a distance of 3 000 ft.? Show all your figures. No tables required.

6. In running a line with a transit instrument by foresights and backsights with several set-ups, would you or would you not get a straight line if you kept foresights and backsights equal; in other words, would instrumental errors be compensated by doing so?

7. Describe two ways of prolonging a straight line accurately.

8. Describe all the ways you know of repeating the readings of an angle for the purpose of accuracy and state the objections, if any, to each; or else, the reason why it will be the most accurate method.

9. Describe clearly the method of measuring a base line for an accurate triangulation in the surveys of the city.

10. (*a*) In what ways are accurate sights more difficult in doing city work than in the open country? (*b*) State how you can overcome these difficulties in each case?

11. State how (that is, describe the operation by which) you would carry a line of survey through a city block covered with buildings and locate and measure all lot intersections as well as external lot measurements; in other words, make a complete and accurate map of the block.

12. (*a*) Suppose you have the courses and length of all the sides of a piece of ground but one. Could you compute the area, and how would you do it? (*b*) In so doing what assumptions would be made?

13. Suppose you wish to determine the area of a piece of ground with a number of sides, which is entirely unobstructed and you have only a chain or tape; how can you do it? Make a sketch.

14. Why is a very small angle undesirable in trigonometric measurements?

15. State a simple arithmetical rule for determining the angle subtended by a very small offset from a transit line at any given distance; state also the explanation of this rule.

Mathematics.

1. Compute the number of square yards of pavement on a curve of which the radius of the center line is 350 ft., the angle at the center is 40°; and the width of the pavement 40 ft.

2. Compute the natural line of an angle in a right-angled triangle of which the hypothenuse is 107 ft., and the side "opposite" the angle is 83 ft.

3. Compute the natural tangent of the "adjacent" angle in the same triangle.

4. Find the contents of the frustum of a cone of which the radii of the bases are respectively 7 ft. and 4 ft. 7 in. and the height 8 ft. 5 in. The prismoidal formula may be used, if it is so desired.

5. The side of a hexagon circumscribing a circle is 12 ft. What is the area of the circle?

MANUAL OF EXAMINATIONS

FOR

ENGINEERING POSITIONS

IN THE

SERVICE OF THE CITY OF NEW YORK

Transitman and Computer

TYPICAL QUESTIONS AND ANSWERS

TYPICAL QUESTIONS AND ANSWERS.

1. State the duties a transitman may be called upon to perform in the City of New York.

A transitman is required to *run* the instrument; to do careful, accurate and rapid work; keep complete, neat, legible notes, and direct the entire work of party.

He must be able to reduce, plot notes, and assist with office work.

He may be called upon to make topographic, street opening, damage and other surveys, to lay out work, and give line and grade for sewers, highways, bridge and other construction work.

2. How would you make up a transit party for the survey of a railroad or aqueduct? Also for the survey of a city block?

A well-composed transit party for the survey of a railroad or aqueduct should be made up as follows: Chief of party, transitman, head and rear chainmen, two flagmen and one axeman or stakeman.

For the survey of a city block a transit party should consist of chief of party (transitman or assistant engineer), instrumentman (leveler or transitman), two chainmen and an axeman.

3. State the duties of each man.

The duties of the chief of party are to direct the survey and see that each man does his work properly.

The transitman runs the instruments, keeps notes, and takes charge of party in the absence of the chief.

The head chainman runs the front end of the chain, obtaining his line from the transitman, and keeps tally of the distances.

The rear chainman runs the rear end of the chain, calls and checks the stationing.

The axeman or stakeman keeps a supply of stakes, accompanies the head chainman and marks them as directed, drives the stakes, clears the line, and makes himself generally useful.

The front flagman establishes points ahead as directed by the chief of party or transitman. He should select transit points that will give both fore and back sight with least possible obstructions.

The rear flagman gives sights on the established transit points.

4. State the adjustments of the engineer's transit.

1. Adjustment of the plate levels; to make them perpendicular to the vertical axis.
2. Adjustment of the cross hairs; to make the line of collimation perpendicular to the horizontal axis.

3. Adjustment of the horizontal axis: to make it perpendicular to the vertical axis.

4. Adjustment of the long bubble (for leveling): to make the line of sight and the bubble axis parallel to each other.

NOTE: While "parallax" is called an adjustment, it is not one in the sense of those above mentioned.

5. What is the very first adjustment of a transit that should always be made and how is it done?

Adjustment of the plate levels: to make them perpendicular to the vertical axis.

Level up, with the bubbles parallel to the leveling screws; reverse 180°. If the bubbles do not remain in the center, correct one-half the error by means of the leveling screws and the remaining half by means of the adjusting screws attached to the plate levels.

Test the adjustment and repeat if necessary.

6. (*a*) What planes should a transit instrument revolve in truly, if in perfect adjustment? (*b*) In case it describes a cone when revolved on its horizontal axis, what adjustment must be made and how is it done?

(*a*) In vertical and horizontal planes.

(*b*) The cross hair adjustment: to make the line of collimation perpendicular to the horizontal axis.

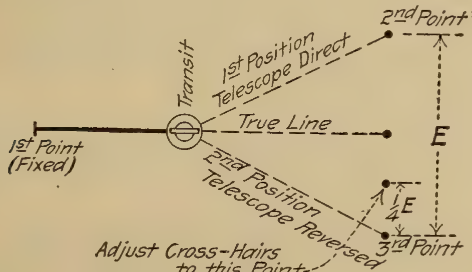
Set up instrument on fairly level ground.

Sight on a fixed point a few hundred feet away. Clamping instrument, *revolve telescope*, and set a point in the opposite direction about the same distance.

Unclamp and *revolve instrument*, setting again on first point, the telescope being reversed.

Now *revolve telescope* again, fixing a third point beside the second. Measure off one-fourth the distance between these two points from the third point, and by means of the adjusting screws on the cross hair ring, bring the line of sight on this point.

Test and repeat if necessary.



7. If the plane described when telescope is revolved vertically is inclined to the vertical, what adjustment must be made and how is it done?

Adjustment of the horizontal axis: to make it perpendicular to the vertical axis.

Set up instrument about 25 ft. from a building or other tall object.

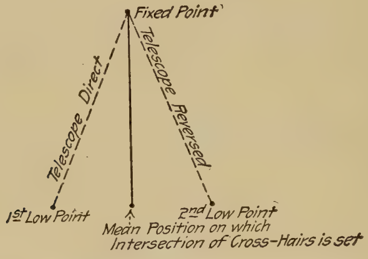
Sight on some fixed high point, clamp instrument, depress the telescope and mark a low point on line.

Reverse telescope and sight on the high point again, depress and mark a second low point beside the first.

The mean of the two lower points is vertically beneath the upper fixed point.

Raise or lower one end of the horizontal axis by means of the adjusting screws until the cross hairs bisect the mean position.

Test and repeat if necessary.



8. Describe the adjustments of the cross hairs. Would the line of sight being out of adjustment affect every angle measured? Explain fully.

(*a*) See Question 6.

(*b*) The line of sight being out of adjustment will not affect angles between points in the same horizontal plane.

The line of sight not being perpendicular to the horizontal axis describes a conical surface when the telescope is revolved. To obtain the correct angle between two points of different elevations we measure the angle between two vertical planes passing through them.

Therefore the angles will not be correct and the error will vary with the difference of elevation.

9. If the transit is furnished with a level tube, what adjustments are necessary to enable it to be used for leveling, and what extra adjustments to be used as a transit?

If the transit is furnished with a level tube, it is necessary to make the axis of the bubble parallel to the line of collimation, if

the instrument is to be used for leveling. This is done by the "Peg method"—see Vol. 1, part 3.

The plate bubbles must also be in adjustment.

To use the instrument for transit work, in addition to latter adjustment, the line of collimation and the horizontal axis must be in adjustment.

10. How often should adjustments of a transit be tested?

Adjustments should be tested on starting out when accurate work is to be done. The tests should be made during the course of the work about once a week. Where the instrument is known to hold its adjustments poorly, the tests should be made more often.

The transitman can usually tell during the course of his work when the instrument requires adjustment.

11. Can accurate work be done with the instrument out of adjustment?

Yes, if the proper steps are taken to eliminate errors.

12. How would the measured angles, with the bubbles out of adjustment be affected?

When the plate bubble is out of adjustment, the vertical axis is inclined. The planes described by the line of sight are therefore not vertical nor equally inclined. The measured horizontal angles will therefore be in error, because horizontal angles between points are the angles subtended by vertical planes through those points and the instrument.

The error will be large or small, depending upon the relative elevation of the points.

13. If the bubble perpendicular to the telescope is out, but the collimation is vertical, will the line be a straight one?

No. If this bubble is out, the vertical axis is inclined, and since the plane generated by the line of sight is vertical, it cannot be directly over the point indicated by the plumb bob. There will thus be a slight cumulative error in each set-up.

14. Suppose the horizontal axis of the telescope be not strictly at right angles to the vertical axis, how would it show itself in the work done?

In this case the line of sight describes equally inclined planes and the measured angles depend upon the difference of elevation between the points, but not upon the size of the angle. The errors will

be plus or minus, depending upon the direction of inclination of the axis and the relative position of the points.

Lines run with the instrument in this condition will not be straight.

15. Suppose there is a vertical limb to an instrument; is there any adjustment or test needed; if so, what?

The vernier of the vertical circle should read zero when the line of sight is horizontal or else the index error should be noted.

16. How would you prolong a straight line from a given back-sight?

Set accurately over point, putting one set of leveling screws in line. Level up carefully, turn upon given back-sight; clamp the instrument and make a careful bisection. Revolve telescope and set a point ahead.

Unclamp and revolve about the vertical axis, making a second bisection upon the rear point, with the telescope reversed. Clamp again and revolve telescope and set a second point ahead, beside the first. The mean position of these two points is on the true prolongation of the line.

Care should be taken that the cross bubble is in the center when sights are taken. This method is called "Double Hubbing," "Double Reversal" or "Double Centering."

17. (*a*) How would you prolong a line for a distance of a mile? Give two methods. (*b*) How would you correct errors made in so running?

(*a*) First method—By "double hubbing." See Question No. 16.

Second method—By foresights. Set on the rear point. Sight on the forward point, and set a new point ahead. Move instrument to forward point, sight on point just established and set another point ahead of this. Continue operation until the mile is run. If possible a long foresight should be fixed ahead, which can be available for different set-ups.

(*b*) If the total error in the line at the end of the mile is known or can be found, the intermediate points may be corrected in position by proportioning the error according to their distances from the starting point.

18. In running a line with a transit by F. S. and B. S. with several set-ups, would you or would you not get a straight line if you kept F. S. and B. S. equal? In other words, would instrumental errors be compensated in so doing?

Not necessarily.

Instrumental errors are not compensated by taking equal sights in running a transit line.

19. In what ways are accurate sights more difficult in doing city work than in open country? State how you would overcome the difficulties in each case.

In the city accurate sights are interfered with by obstructions and traffic, disturbance and jar of the instrument, etc. To overcome difficulties due to obstructions and traffic, select times when these are least, or arrange sights that will not be obstructed. To overcome the effect of jar and distrubance due to vehicles or pedestrians, the instrument should be as far removed from them as possible and should be firmly set up and carefully watched.

20. What is meant by the double reversal method?

It is an accurate method of prolonging straight lines to eliminate errors of adjustment. It consists in fixing two points ahead beside each other, one with the telescope direct and the other with it reversed, the backsight being fixed. The mean of the two points thus obtained is on the true line.

See also Question No. 16.

21. When prolonging a line, which is most accurate, reversing 180° on limb, or revolving the telescope? What is the most accurate method of prolonging a line?

Revolving telescope is the more accurate.

The "double reversal" method is the most accurate. See Question No. 16.

22. If a line is run from a point a and it is afterward found that the line run is a short distance x from the point, what arithmetical calculation would you employ to find the correction for the angle at a?

Use proportion.

Angle a : 180° :: error x : distance $\times$ 3.1416, and calculate angle a.

23. If it were necessary to cut a street through a block that was built up, how would you run the line?

Run the line through any available openings in the buildings, such as alleyways, halls, windows, etc., by offsetting from the center line, or traverse lines.

If this is not feasible, offset the line to the next street, as in the case of an obstruction.

24. State all the sources of error that may occur in transit work.

1. Instrumental errors, embracing errors of adjustment, eccentricity of centers and verniers, and defective construction.

2. Errors of observation, embracing errors of bisection, parallax, errors in reading verniers, personal errors of observation, unsteady and indistinct sights, and using too short sights.

3. Errors in setting up, embracing inaccurate centering over point, not setting up firmly, disturbance of instrument after setting up, and carelessness in handling.

4. Errors due to natural conditions, such as wind, sun, air, tremor, snow, ice and frost, dust and fog.

25. Where the best and most accurate work with a transit is required, describe every precaution requisite on the part of the transitman in adjusting, handling, protecting and sighting his instrument.

Adjust the instrument carefully on starting work and test frequently during the course of the work. The adjusting screws should be firmly set, but not strained.

In handling the instrument the transitman should see that the instrument is not jarred, that the head swings freely in carrying, that the clamps in setting the instrument should be snug, but not strained, that there should be no lost motion either in the instrument or the tripod.

In protecting the transit keep it clean and free from rain and dust. A waterproof cover should be provided for the purpose. It should be shielded from sun and wind. When not in use and when carried on vehicles it should be kept in the box.

In sighting always focus carefully and avoid parallax. Make accurate bisections, eliminate errors by the reversal method and by repetition, and avoid eccentricity by reading both verniers.

26. (*a*) What causes are there for errors in long sights? (*b*) Can these be guarded against in any way and, if so, how?

(*a*) Poor sights, their indistinctness due to atmospheric conditions or low power of instrument. In long sights the space covered by cross hair is relatively large, thus making accurate bisections more difficult. The effect of wind and disturbance of instrument is magnified.

(*b*) These can be guarded against by doing the work under the most favorable atmospheric conditions, by having a good telescope and using fixed and well defined sights.

27. What, in your opinion, is the best length of sight, and why?

The longer the sight consistent with distinctness the better. With good sighting boards and a good transit, sights as long as a mile and more may be taken.

In reading angles the longer the sights, the smaller will the angular error be, due to imperfect bisection, adjustments, setting over point, etc.

The length of sight is limited only by the power of the telescope, atmospheric conditions and nature of sights themselves.

28. What effect does the heat of the sun have on transit work?

The sun's heat causes unequal expansion of different parts of the instrument. It produces shortening of bubbles, air tremor, glare both on the sight and the object glass, thus affecting the accuracy of the work, as well as its rapidity.

29. What time of year and what conditions of weather are best adapted to most accurate transit work, and why?

Accurate transit work can best be done in the fall, when the ground is most stable and the temperature most uniform. A perfectly calm, cloudy day, with a clear atmosphere and a temperature of from 40 to 60°, offers the best conditions of weather.

30. Describe all the causes of error in reading the limb of a transit.

Errors in reading the limb may be made by parallax in reading the verniers, by using a poor or no reading glass, by reading on the wrong side of the vernier or in wrong direction on limb, by reading the wrong graduations, and not by shading the vernier.

31. How are errors in reading the limb and in graduation of the instrument guarded against or minimized?

The errors may be minimized by reading both verniers and reading on different parts of the limb, by using a good reading glass and observing care in reading the verniers and graduations, by shielding the verniers from glare of the sun, by having the readings checked. By reading angles by repetition, using different portions of the limb, errors in graduation are minimized.

32. In the use of a good transit of ordinary size, what would you expect the average error in each of a number of angles to amount to?

From two to five seconds per angle, depending on number of angles, lengths of sights, etc.

33. Suppose you find the errors to be very considerable; is there any way by which you can determine where errors can probably be found? State what you would do.

1. Compare magnetic bearings with computed bearings.
2. Where the polygon can be split up into smaller ones in which the angles have been read, test each.
3. Where supplementary angles have been taken, they will help to locate error.

34. If an error of one minute be made in reading an angle, what would be the offset from the true line at a distance of 3 000 ft.?

Use proportion:

Offset: 3.1416 $\times$ distance :: error in angle in minutes : 180 $\times$ 60, giving at 3 000 ft. an offset of 0.873 ft.

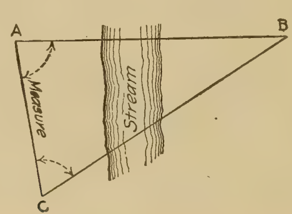
35. How would you determine the distance between two inaccessible points?

Measure a base line with the inaccessible points visible from either end. Set up at each end of the base and read the angles from the inaccessible points to the base. From the data thus obtained calculate the required distance.

36. How would you measure an angle made by two lines at an inaccessible point?

Establish a point on each of the lines visible from the inaccessible point and from each other. Set up on them and read the angle between each line and the line joining the points. Add the two angles thus obtained and subtract their sum from 180°. The difference will be the required angle.

37. Suppose you had to measure the distance between two objects on opposite sides of a stream without crossing it. Describe the instrumental work necessary. Make a sketch and show the method of making the computation of the distance.



Let A and B be the two objects. Set up on A. Establish a pcint C (visible from A and B) on the same side, so that $A\ C$ will be about equal to $A\ B$. Measure line $A\ C$ and angle at A. Now set up at C and measure angle at C. Two angles and the included side being thus known, $A\ B$ is computed from proportion

$$A\ B : A\ C :: \sin.\ C : \sin.\ B.$$

38. Suppose obstructions to one of the sides to require that one angle be sighted to an offset stake, what is the form of simple proportion by which you can determine the small angle required to ccrrect the sight requiring no tables for its use?

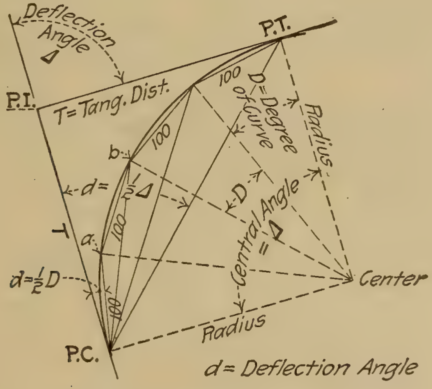
The small angle : 180° :: the offset : dist. $\times$ 3.1416. See Question No. 22.

39. What is meant by the degree of curvature of a curve and how is it used?

The degree of curvature of a curve is the number of degrees in the central angle subtended by a chord of 100 ft.

It is used in designating the sharpness of a curve and computing deflections, etc., for staking out curve.

40. How would you join two lines by a simple curve? Show your notes.



Prolong the two lines until they meet at P. I. and measure the deflection angle.

Decide upon the degree of curve. Compute the tangent distance T.

Lay off the computed distance T from this point of intersection (P. I.) on each of the lines, giving the beginning (P. C.) and the end (P. T.) of the curve.

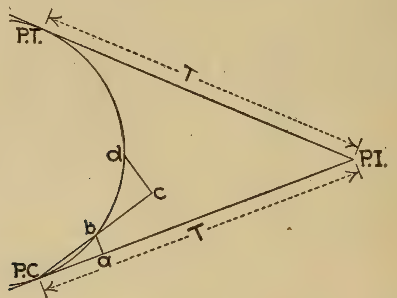
Set transit at the P. C. with vernier reading zero, sight on P. I. Turn off angle equal to half the degree of curve to *a*, 100 ft. from P. C. Drive stake at *a*.

Then deflect $2 \times \frac{1}{2}$ degree of curve and measure 100 ft. from *a*, giving *b*, the second point on the curve.

Proceed in this manner until the deflection equals one-half the central angle, when, if the work is correct, the last point will coincide with the P. T.

Station.	Bearing.	Deflection.	Vernier.	Remarks.
13 + 00	....	....	....	$L = 100\frac{\Delta}{D} = \frac{12 \times 100}{2} = 6$
△ *P. T.* 12 + 00	*N* 52 *E*	12° *R*	6° 00	$\Delta = 12° 00$ $D = 2° 00\ R$
11 + 00	....	....	5° 00	$R = 28.65$
10 + 00	....	....	4° 00	$P.\ I. = 9 + 00.8$
9 + 00	....	....	3° 00	$T. = 300.8$
8 + 00	....	....	2° 00	$P.\ C. = 6 + 00$
7 + 00	....	....	1° 00	$L = 600$
△ *P. C.* 6 + 00	*N* 40° *E*	....	....	$P.\ T. = 12 + 00$
5 + 00				
4 + 00				

41. How would you lay out a curve without an instrument?



Prolong lines to P. I. Compute T., and set stakes at P. C. and P. T.

Measure 100 ft. from P. C. along tangent to *a*. Lay off the tangent offset from *a*, giving *b*, a point on the curve. Prolong the chord through *b* 100 ft. to *c*. From *c* lay off the chord offset, giving *d* another point on curve. Prolong chord through *d* and proceed as before until P. T. is reached.

NOTE.—Tangent offset is equal to the chord squared divided by twice the radius. Chord offset equals twice tangent offset.

42. What other ways are there of laying out curves?

Besides the methods of deflections and tangent offsets curves may be laid out by middle ordinates, by swinging the arc (the center being accessible and radius convenient), by ordinates from the long chord, and by offsets from the tangents.

43. Describe all the ways you know, of repeating the readings of an angle for the purpose of accuracy. State all the objections, if any, or why you consider it the best method.

1. By method of repetition. See Question 44. This method permits a closer value of the angle to be obtained than could be done by a single reading.

2. By method of reversal. By taking one set of repetitions, say, in a clockwise direction, with the telescope normal, and another set with the telescope reversed in an anti-clockwise direction, errors of collimation, horizontal and vertical axes, also errors of twist and lost motion are eliminated. By reading both verniers errors of eccentricity of verniers are eliminated.

3. By series. By taking complete sets of readings with verniers set at different portions of the limb on starting, errors of graduation and eccentricity of plates are eliminated.

44. How would you measure an angle accurately? Give your method in detail.

Set up instrument carefully over point.

Read the angle and record the reading, using both verniers.

Repeat the readings of the angle, adding the successive readings on the limb and divide the total angle by the number of repetitions.

In making the repetitions, take one-half the readings with the telescope normal and one-half with the telescope reversed.

NOTE.—To make a repetition proceed as follows: Set vernier *A* at zero. Sight on first station, clamp lower and unclamp upper motion, and sight on second station. Record the angle. Now unclamping lower motion, sight again on first station and clamp. Then unclamping upper motion, sight again on second station. The reading on the limb will be twice the angle. Repeat this operation as often as desired, noting the number of repetitions. See also Question 43.

45. Describe clearly the method of measuring a base line for an accurate triangulation survey in the city.

Set up transit over one end of the base line and sight on a fixed flag on the other end or on an intermediate point already established.

Use a 100-ft. steel tape with a compensating spring balance and thermometer attachment, which has been compared with a standard and whose error is accurately known.

Points may be marked on flagging by fine scratches; on macadam by fine tacks or by using chaining plates, spikes, or spiders on which to mark points.

The rear chainman plumbs the zero end carefully over the starting point; the front chainman applying the proper pull, holds the tape level on line. At proper signals, the front chainman fixes the forward point; this point is then tested and if it checks the chain is carried ahead for the next measurement.

The operation is repeated until the entire base has been chained. Plusses are obtained by the graduated tape.

The base should then be measured in the opposite direction and the mean of the two determinations taken.

Permanent points should be established at convenient intervals along the line.

46. How would you make a survey for a reservoir and calculate its capacity?

First. Run a traverse and establish bench marks around the reservoir site.

By means of the plane table, or the transit and stadia, or by cross-sectioning, make a topographical map showing contours, roads, buildings, streams, fences and all other topographical features. The contours should be at intervals of 5 to 10 ft. See also Question No. 48.

To caluclate the capacity find, by means of the planimeter, the horizontal area included within each contour. Then find capacity by average end area method. The capacity can also be calculated by plotting cross-sections of the reservoir site, and applying the average end area method.

47. State how, that is, describe the operation by which you would carry a line of survey through a city block covered with buildings and locate and measure all lot intersections as well as internal lot measurements. In other words, make a complete and accurate map of the block.

Run an accurate auxiliary traverse around the block, tying same to the line of survey, establishing and referencing traverse points. Where possible these lines should be parallel to the building lines of the block.

Obtain rectangular offsets to outside corners of all buildings, curbs, fences, manholes, hydrants and all other features, noting, if possible, the stationing of same along the transit lines. Location may also be made by angle and distance.

Run tie lines through alleys, doorways, windows or other openings in the buildings and obtain offsets to interior building corners, fence corners, lot intersections, etc.

Measure the frontages of all buildings and lots. Sketch in notebook the plan of the block, showing all lot lines, lot corners, building lines and corners, party lines, if any; also the plan of buildings, giving all measurements and all other information necessary to plot survey. Indicate character of buildings and number of stories, etc., in each.

48. Describe fully the making of a topographical survey with a transit and stadia rod.

The transit should be supplied with a compass and a vertical arc. The rods should be of the self-reading pattern, easily read from the instrument.

Make all adjustments and note the index error of the vertical arc.

Stake out a line about 600 ft. long, setting points 100 ft. apart. Set up the transit on one end of this line and take stadia readings on each point. From the data thus obtained determine the stadia interval of the instrument, taking into account the focal distance of the object glass.

Run a traverse around the area to be surveyed, obtaining the lengths of the sides with the stadia, and their azimuths; establish B. M.'s around traverse.

The azimuth of the first course may be found by an observation on Polaris or by traversing from known lines. To get the azimuth of the succeeding course set vernier on the azimuth of the back course sight on back station with the telescope normal, plunge telescope and turn on forward station. The reading on the limb will be the new azimuth. The backsights and foresights should be averaged for the lengths of the courses, and the lengths reduced to the horizontal.

After the traverse has been closed set up on the transit stations, take shots to all prominent points, such as tops of ridges and bottoms of hollows, fences, buildings, roads and streams, noting the azimuths, vertical angles and distances to each and filling in by sketches all other topographic details. Establish auxiliary transit stations wherever necessary.

When a transit station is once occupied, care should be taken that all necessary data are obtained from it.

By means of a stadia chart or table reduce the observed distance to the horizontal. The notes should be plotted as soon as possible while still fresh in the mind.

The contours are then interpolated between the points of known elevation.

49. Suppose you wish to determine the area of a piece of ground with a number of sides, which are entirely unobstructed, and you have only a chain or tape; how can you do it?

From a point within, measure the distances to the corners of the piece of ground, dividing it into triangles. Measure all the sides. The area of each triangle is found by the formula, Area $= \sqrt{s(s-a)(s-b)(s-c)}$ in which a, b and c are the sides and s half their sum.

The sum of these triangles gives required area.

50. What is the D. M. D. of a course? How obtained?

The D. M. D of a course is twice the distance of its middle point to the meridian of the survey, or the sum of the meridian distances of its extremities. It is equal to the D. M. D. of the preceding course plus the departure of the preceding course plus the departure of the course itself.

51. After the D. M. D. is found, how do you find the area?

Multiply the D. M. D. of each course by its corresponding latitude, take the algebraic sum of the products and divide it by 2. The result will be the area.

52. What check is there after computing the D. M. D.'s of a survey?

The D. M. D. of the last course must be equal to its departure.

53. How would you close an angular survey?

Add up the interior angles in the survey. The sum of the angles should equal $180° \times$ the number of sides $- 360°$.

The difference between this theoretical sum and the sum of the measured angles is the error of closure.

Adjust the angles by distributing the error of closure equally among the several angles. Where it is possible to apportion weights to these angles the error should be distributed accordingly.

If the error is large, mistakes should be looked for in the notes. Where magnetic bearings have been taken they should be compared with computed bearings.

54. (*a*) Suppose you had the courses and length of all the sides of a piece of ground but one, could you compute the area and how would you do it? (*b*) In so doing what assumption would be made?

(*a*) Yes.

Take the differences between the sums of the north and south latitudes and the sums of the east and west departures to obtain the latitude and departure of the missing course. Compute the area as explained in Question No. 57.

(*b*) In calculating the area the assumption is made that the work has been done without error; in other words, that the survey balances perfectly.

55. State a simple arithmetical rule for determining the angle subtended by a very small offset from a transit line at any given distance. State also the explanation of the rule.

The small angle : 180° :: the small offset : dist. $\times$ 3.1416. The offset, being small, is assumed to be equal to an arc whose radius is equal to the distance.

In any circle the arcs are measures of the angles they subtend, so that the arc is to the semi-circumference or 3.1416 $\times$ radius :: its angle : 180°.

56. How are field errors determined? How distributed? Give all details, starting from notes.

The errors are of two kinds: errors in angles and errors in distances. The angular errors are determined and distributed as described in Question No. 53.

After the angles are adjusted, the bearings are computed, the latitudes and departures of the courses tabulated, and their totals obtained. The differences between the northings and southings and between eastings and westings show the error of closure, which is equal to the square root of the sum of the squares of these differences.

By comparing this error of closure to the entire perimeter, the degree of accuracy of the work is shown.

The differences between the north and south latitudes and the east and west departures are then distributed among the latitudes and departures applying to each course an amount depending on the ratio of its length to the entire perimeter. If the error is large the computation should be looked into, and the notes examined.

57. How great must error be to render it necessary to inquire as to causes, or to resurvey?

With an ordinary transit and fairly careful work, the error should not be more than ten seconds per angle, and the error of closure should not be more than one in ten thousand. If the errors exceed these limits the work should be inquired into.

58. How would you calculate the area of a piece of land after the survey has been made?

Balance the survey. Compute the double meridian distance of the courses. Multiply double meridian distance of each course by its corresponding latitude. Take the algebraic sum of these products, divide the sum by two and the result will be the area required.

59. The survey having been made and the area calculated, how would you check the work graphically?

Plot the survey by means of the computed co-ordinates.

Check plotted angles and lengths of courses. These should agree with field measurements.

The area of the plot is then checked by means of a planimeter.

If co-ordinate paper is used, the area can be checked by counting squares. The polygon may also be cut up into triangles, whose areas can be calculated from scaled bases and altitudes.

60. Give form of tables for balancing a survey. Explain its use.

Stations.	Courses.	Dif. Lat.			Departure.		Balanced.		D. M. D.	+ Area.	— Area.
	Bearings.	Dist.	N. +	S. —	E. +	W. —	Lat.	Dep.			
		Ch.									
A.	S. 69° 15′ E.	7.06	......	2.50	6 60	......	— 2.52	+ 6.61	6.61	....	16.66
B.	N. 37° 15′ E.	5.93	4.72	......	3.59	.....	+ 4.71	+ 3.60	16.82	79.22	......
C.	N. 3 ° 30′ W.	6.00	4.63	......	......	3.82	+ 4.62	— 3.81	16.61	76.74	......
D.	S. 57° 45′ W.	4.65	......	2.48	......	3.93	— 2.49	— 3.92	8.88	....	22.11
E.	S. 30° 00′ W.	4.98	......	4.31	......	2.49	— 4.32	— 2.48	2.48	....	10.71
		28.62	9.35 9.29	9.29	10.19	10.24 10.19				155.96 49.48	49.48
									2	106.48	

Error in Lat. = .06; Error in Dep. = .05. Area = 53.24 sq. ch.

= 4.324 Acres.

$$\text{Error of closure} = \frac{\sqrt{5^2 + 6^2}}{2862} = 0.0027$$

$$= 1 \text{ in } 366.$$

(NOTE: From Johnson's "Surveying.")

The use of the table is fully explained by the survey calculated above.

61. In plotting, which is better, to use bearing and distance continually or to use sines and cosines?

Sines and cosines.

62. How is the error apportioned in plotting?

Find, by scaling or calculation, the error in latitudes and departures. Then distribute this error among the courses by changing the latitude and departure according to the weights assigned to them. Plot the corrected points and join them, and the plat will close.

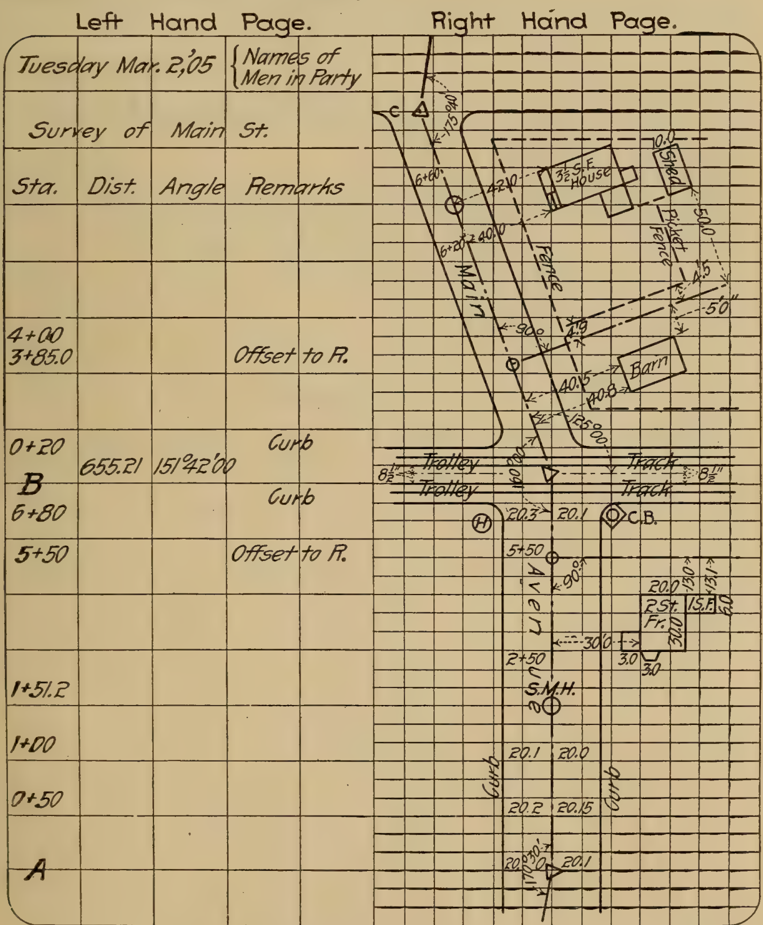
63. How does the use of logarithms facilitate computations? Give rule for finding characteristic.

By changing the operations of multiplying and dividing into, adding and subtracting. The process of extracting roots becomes one of simple division and that of raising to powers becomes one of simple multiplication.

The characteristic is equal to the number of places which the left hand most digit is removed from the unit's place. If to the right, it is minus; if to the left, it is plus, *e. g.*, characteristic of 6,432, = + 3, of .006432 = — 3.

64. Give a sample of notes as you would record them in your notebook of a street half a mile long having several angles and crossing other streets.

Character & Location of Survey



65. An area of ground is to be used as a borrow pit. It has been laid out by lines at right angles to each other at equal distances, and the cuts at each intersection determined. How would you determine the cubical contents?

Take the cut at each intersection as many times as there are partial areas adjoining it; add them all together and multiply by one-fourth area of a single rectangle. This gives volume in cubic feet. For volume in cubic yards divide by 27.

66. What is the limit of error in chaining allowed in measurements on city streets?

In accurate base line measurements from .01 ft. to .02 ft. per 1 000 ft. For secondary traverses and locations, .05 ft. to .1 ft. per 1 000 ft.

67. How many parts are there in any plane triangle and how many must be given in order to solve it? State the problems that may arise to find remaining parts.

There are six parts and three must be given, at least one of which must be a side. The problems that may arise are :

1. Two sides and an angle opposite one of them.
2. Two sides and included angle.
3. One side and two angles.
4. Three sides.

68. In which case is there more than one solution?

When two sides and an angle opposite one of them are given.

APPENDIX.

SOME USEFUL SURVEYING FORMULAS.

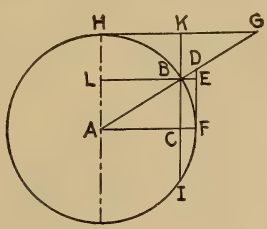
NOTE.—The collection of formulas included in this volume is not intended to be complete in any sense, but it contains a fairly comprehensive list of the more common formulas used in surveying with which candidates ought to be familiar, and it will serve as a ready reference to those preparing themselves for examinations.

Logarithms:

$$\log (a \times b) = \log a + \log b.$$
$$\log (a \div b) = \log a - \log b.$$
$$\log a^b = b \log a.$$
$$\log \sqrt[b]{a} = \log a \div b.$$

Trigonometric Functions:

Angle $BAC = A$; Angle $CBA = B$.
$CB = a$, $CA = b$, $AB = c$.



$\text{Sin } A = \cos B = \frac{a}{c} = a$ when radius $= 1$.

$\text{Cos } A = \sin B = \frac{b}{c} = b$ " " "

$\text{Tan } A = \cot B = \frac{a}{b} = FD$ " " "

$\text{Cot } A = \tan B = \frac{b}{a} = HG$ " " "

$\text{Sec } A = \operatorname{cosec} B = \frac{c}{b} = AD$ " " "

$\text{Cosec } A = \sec B = \frac{c}{a} = AG$ " " "

$\text{Vers } A = 1 - \cos A.$

$\text{Sin } 2A = 2 \sin A \cos A.$

$\text{Cos } 2A = 1 - 2 \sin^2 A.$

$$\text{Sin } \tfrac{1}{2} A = \sqrt{\frac{1 - \cos A}{2}}$$

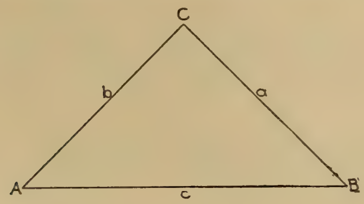
$$\text{Cos } \tfrac{1}{2} A = \sqrt{\frac{1 + \cos A}{2}}$$

VALUES OF THE SIX PRINCIPAL FUNCTIONS OF ANY ANGLE x, IN TERMS OF ONE ANOTHER.

	sin. x.	cos. x.	tan. x.	cot. x.	sec. x.	cosec. x.
sin. x........................	1	$\sqrt{1-\cos.^2 x}$	$\frac{\tan. x}{\sqrt{1+\tan.^2 x}}$	$\frac{1}{\sqrt{1+\cot.^2 x}}$	$\frac{\sqrt{\sec.^2 x-1}}{\sec. x}$	$\frac{1}{\operatorname{cosec.} x}$
cos. x........................	$\sqrt{1-\sin.^2 x}$	1	$\frac{1}{\sqrt{1+\tan.^2 x}}$	$\frac{\cot. x}{\sqrt{1+\cot.^2 x}}$	$\frac{1}{\sec. x}$	$\frac{\sqrt{\operatorname{cosec.}^2-1}}{\operatorname{cosec.} x}$
tan. x........................	$\frac{\sin. x}{\sqrt{1-\sin.^2 x}}$	$\frac{\sqrt{1-\cos.^2 x}}{\cos. x}$	1	$\frac{1}{\cot. x}$	$\sqrt{\sec.^2 x-1}$	$\frac{1}{\sqrt{\operatorname{cosec.}^2 x-1}}$
cot. x........................	$\frac{\sqrt{1-\sin.^2 x}}{\sin. x}$	$\frac{\cos. x}{\sqrt{1-\cos.^2 x}}$	$\frac{1}{\tan. x.}$	1	$\frac{1}{\sqrt{\sec.^2 x-1}}$	$\sqrt{\operatorname{cosec.}^2 x-1}$
sec. x........................	$\frac{1}{\sqrt{1-\sin.^2 x}}$	$\frac{1}{\cos. x}$	$\sqrt{1+\tan.^2 x}$	$\frac{\sqrt{1+\cot.^2 x}}{\cot. x}$	1	$\frac{\operatorname{cosec} x}{\sqrt{\operatorname{cosec.}^2 x-1}}$
cosec. x......................	$\frac{1}{\sin. x}$	$\frac{1}{\sqrt{1-\cos.^2 x}}$	$\frac{\sqrt{1+\tan.^2 x}}{\tan. x}$	$\sqrt{1+\cot.^2 x}$	$\frac{\sec. x}{\sqrt{\sec.^2 x-1}}$	1

NOTE.—Complete relations given although not required by the question.

Solution of Plane Triangles.



Given A, B, a. Sought C, b, a.

" $C = 180° - (A + B)$. Use $a : b :: \sin A : \sin B$.

" A, b, a. Sought B, C, c. Use $a : b :: \sin A : \sin B$. (two solutions).

" C, a, b. Sought A, B, c. $A + B = (180 - C)$;

then use $(a + b) : (a - b) :: \tan \frac{1}{2} (A + B) : \tan \frac{1}{2} (A - B)$,

also $C = \sqrt{a^2 + b^2 - 2\, a\, b \cos C}$.

Given a, b, c. Assume $s = \frac{1}{2} (a + b + c)$.

Then $\sin \frac{1}{2} \mathrm{A} = \sqrt{\frac{(s - b)\,(s - c)}{b\, c}}$

Mensuration.

Area Triangle $= \frac{1}{2}$ (base $\times$ altitude).

$= \sqrt{s\,(s - a)\,(s - b)\,(s - c)}$.

$= \frac{1}{2}\,(a\, b \sin C)$.

" Parallelogram $=$ base $\times$ altitude.

" Trapezoid $=$ sum of bases $\times \frac{1}{2}$ altitude.

" Trapezium $=$ diagonal $\times \frac{1}{2}$ sum of altitudes.

Circles:

Circumference $= \pi \times$ diameter $= 3.1416\, d$.

Area $= \pi\, r^2 = \frac{1}{4}\, \pi\, d^2$.

Length of arc $= \frac{\text{number of degrees in arc}}{360} \times$ circumference

Area of sector $= \frac{\text{number of degrees in central angle}}{360} \times$ area.

Area of segment = area of sector — area triangle formed by chord of segment and radii.

Area of circular ring $= \pi (R^2 - r^2)$, R and r being radii of large and small circles, respectively.

Ellipse:

Area $= \frac{\pi}{4} D\, d$, D and d are the major and minor axes.

Circumference (approximate) $= \pi \sqrt{\frac{D^2 + d^2}{2}}$

Regular Polygons:

Area $= \frac{1}{2}$ perimeter $\times$ perpendicular distance from centre to any side.

Irregular Polygons—To Find Area:

Divide polygon into triangles, and find sum of the areas of these triangles.

Or plot polygon on cross-section paper and count squares included within perimeter,

Or use a planimeter.

Prism or Cylinder:

Surface = areas of 2 bases + (perimeter of base $\times$ altitude).
Volume = area of base $\times$ altitude.

Pyramid or Cone:

Surface = area of base + (perimeter $\times$ $\frac{1}{2}$ slant height).
Volume = area of base $\times$ $\frac{1}{3}$ altitude.

Frustum of Pyramid or Cone:

Surface = areas of 2 bases + $\frac{\text{sum of perimeters of bases}}{2}$ $\times$ slant height.

Volume $= (A_1 + A_2 + \sqrt{A_1 A_2}) \frac{\text{altitude}}{3}$, in which A_1 and A_2 = areas of the bases.

Or, by Prismoidal Formula:

Volume $= (A_1 + A_2 + 4\, A_m) \frac{\text{altitude}}{6}$, in which A_m = area of section midway between A_1 and A_2.

For ordinary earthwork computation, use average end area method:

Volume $= \left(\frac{A_1 + A_2}{2}\right) l$, in which A_1 and A_2 are the end sections and l the distance between them.

Wedge:

Volume $= \frac{1}{6} \times$ (length of edge + twice the length of back) $\times$ perpendicular distance of edge to back $\times$ width of back.

Sphere:

Surface $= \pi D^2$.

Volume $= \frac{1}{6} \pi D^3$.

D = diameter of great circle.

Latitude of a course = distance $\times$ cosine of bearing.

Departure of a course = " $\times$ sine of bearing.

Double meridian distance of a course (D. M. D.) = D. M. D. of preceding course + departure of preceding course + departure of course itself.

Area of survey $= \frac{1}{2}$ algebraic sum of products of the D. M. D.'s by their corresponding latitudes.

Error of closure $= \sqrt{\text{latitude}^2 + \text{departure}^2}$.

Stadia Formula (for Horizontal Sights):

$$D = \frac{f}{i} s + f + c.$$

D = correct distance from instrument to rod.

f = focal length of object glass.

c = distance from center of instrument to object glass.

s = intercept on rod.

i = distance between cross-wires.

Correction for Curvature and Refraction:

$C = \frac{2}{3} D^2$.

D = distance in miles.

C = correction in feet (to be added).

$R = \frac{1}{7} C. \qquad F = C - R = \frac{4}{7} D^2.$

R = correction for refraction (to be subtracted).

F = resultant correction for both curvature and refraction (to be added).

Curves:

$$R = \frac{50}{\sin D}.$$

$$d = \frac{1}{2} D = \frac{50}{R}.$$

$$T = R \sin \tfrac{1}{2} \triangle.$$
$$C = 2\ R\ \sin\ D.$$
$$d_c = \frac{C^2}{R}.$$
$$d_t = \frac{C^2}{2R}.$$
$$m = \frac{C^2}{8R}.$$
$$L = 100 \frac{\triangle}{D}.$$

L = length of curve.
D = degree of curve.
R = radius of curve.
d = deflection angle.
T = tangent distance.
$\triangle$ = central angle.
d_c = chord deflection.
d_t = tangent "
m = middle ordinate.
C = length of chord.

Allowable Errors in Chaining:

With link chain 1 ft. in 500 traverses should close 1 in 1 000.
With graduated tape, rough work 1 foot in 2 000, 1 in 5,000.
Fairly accurate work, 1 ft. in 5 000, 1 in 10 000.
Very careful work, 1 ft. in 15 000, 25 000.
With spring balance and compensating attachment, fairly accurate work 1 ft. in 20 000, 30 000.
Very accurate work 1 ft. in 40 000, 60 000.

Allowable Errors in Angular Work with Transit:

Rough work,	10 seconds per angle.				
Ordinary work,	5	"	"	"	
Accurate,	2	"	"	"	
Very accurate,	1	"	"	"	or less.

Allowable Errors in Leveling:

With hand level,	1 ft. per mile.
With accurate level, rough work,	$.1 \times \sqrt{\text{distance in miles}}$.
Ordinary work,	$.05 \times \sqrt{\text{distance in miles}}$.
Very accurate bench levels,	$.03 \times \sqrt{\text{distance in miles}}$.

ERRATA—VOL. II.

NOTE.—Owing to necessary haste in the preparation of Part II, so as to make it available for the examination held in June, some typographical errors have crept in, which are enumerated below.

PART I.

Page 25, question 13: "Taking equal back and foresights" should read "taking reciprocal sights."

PART II.

Page 45, question 5, line 3: "4° C" should read "standard temperature."

Page 50, question 19, 3d line from bottom: Insert after formulas "in which *a* is the vertical angle."

Page 66, question 57, line 9: "Constructed of two layers" should read "constructed of two rows."

Page 73, question 79, line 2: "Of the bottom" should read "*at* the bottom."

Page 73, line 8: "110 lbs." should read "*100* lbs."

Page 73, line 21: "Moments" should read "moment."

Page 75, question 83, 4th line from bottom: "Unit pressure of" should read "unit pressure *on*."

Page 86, question 93, under notation: Replace "*L*" by "*l*."

Page 87, question 95, 4th line from bottom: Replace "*as*" by "*is*."

Page 94, question 113: "8.05" should be "8.5."

Page 96, question 118: Σt should read ΣT; same line, insert comma before *d*.

Page 102, question 137: Insert under cut, "rain gauge."

Page 107, question 145: "To form a water tight mixture" should follow "the puddle should be."

Page 111, question 153: "498.15" should be "498.75."

Page 111, question 153, 2d line from bottom: "6.57" should follow last = sign.

Page 112, question 153, line 4: "Coefficient of function" should read "coefficient of friction."

Page 124, question 173, line 3: "Barbor" should be "harbor."

Page 135, 12th line: "A too low" should read "too low a."

Page 139: (Area) $\frac{3}{4}$ should be (Area) $^{\frac{3}{4}}$.

MANUAL OF EXAMINATIONS

FOR

ENGINEERING POSITIONS

IN THE

CIVIL SERVICE OF THE CITY OF NEW YORK

QUESTIONS AND ANSWERS

IN *3* VOLUMES

VOL. I. AXEMAN, CHAINMAN AND RODMAN, LEVELER, TRANSITMAN AND COMPUTER

VOL. II. ASSISTANT ENGINEER

VOL. III. DRAUGHTSMAN, AND INSPECTOR

VOL. II. PART I

ASSISTANT ENGINEER

RAPID TRANSIT COMMISSION

INDEX

NEW YORK

THE ENGINEERING NEWS PUBLISHING COMPANY

1906.

PREFACE.

In the "Previous Examination Papers" which have been included in this book, the questions may not, in all cases, be identical in wording with those actually given at the examinations, as copies of the original papers are not readily procurable, but they do embody the substance of the questions asked.

In the section devoted to "Typical Questions and Answers," the answers indicate in a general way only what is required of the candidate, and are not intended to be perfect and complete, as reasonable variance of opinion may exist as to what is the best answer in many cases, owing to differences in interpretation of the question and in education and experience.

The general plans, details, specifications and methods pursued in the construction of the New York Rapid Transit Subway are fully described and illustrated in the volumes of *Engineering News* covering the period of construction.

In order to perpetuate the value of this book, blank leaves have been inserted after the "Previous Examination Papers," allowing for the convenient addition of new sets, and the "Typical Questions and Answers" have been interleaved, to provide space for notes, sketches and additions.

PREVIOUS EXAMINATION PAPERS.

PRELIMINARY EXAMINATION, RAPID TRANSIT COMMISSION.

TECHNICAL PAPER.

NEW YORK, October 9, 1899.

Salary, $1 200.

1. (*a*) What do you understand by the term "angle of repose" of earth? (*b*) Where is the center of pressure in a retaining wall, earth level with top?

2. (*a*) Within what limits should the line of thrust come in the abutment of an arched bridge to insure stability? (*b*) What should be the proportion of "headers" to "stretchers" used in a retaining wall?

3. What pressure per square foot can safely be placed on the following materials when ground is continually wet: (*a*) clay, (*b*) loam, (*c*) gravel?

4. What is the difference between refraction and reflection and what is the effect of the former on the line of sight of a level?

5. In running a line of levels with sights 1 600 ft., what method would you use to insure accuracy and allow for refraction and curvature?

6. What are the physical properties of cast iron, wrought iron and wrought steel, that make them useful in engineering works? State briefly how they should be tested and what uses they are best fitted for.

7. Give essential points in specification for timber piles and pile driving.

8. What are the various ways of using and shaping sheet piling to keep water away from work?

9. What is hydraulic cement and how should different samples be tested?

10. Write monthly estimate for some public work, giving at least six items, carry out the arithmetic, assume prices that you believe correct for such work, show amount retained, previous payments, etc.

Mathematical Paper.

1. Given a culvert; what will be the cubic feet per second of water reaching the culvert draining 1 000 acres? Assume formula as follows:

$$Q = c\,y\,\sqrt[4]{s\,a^3}$$

Q = Cubic feet per second reaching culvert.
c = Proportion of rainfall.
y = Rainfall per hour in inches.
s = Slope in feet per 1 000 ft.
a = Number of acres drained.

Assume values for c, y, and s according to your judgment.

2. If 12 men shovel 90 yd. of earth in one hour and a half, how many men will be required to shovel 2 500 yd. of earth in ten hours?

3. Extract square root of 49 783.96.

4. Given a pair of rafters, span 50 ft., angle 30°; what will be the length of rafters and strain on each?

Report Paper.

Write a report, covering at least two pages, on some important work, stating design selected, reason for selecting it and report progress in the work up to a certain period. Give such information as the chief engineer would expect to find in such a report.

Experience Paper.

1. Have you pursued a course of study in any school or college which fits you for the position of assistant engineer; if so, give length of course? Did you graduate or receive a degree or diploma?

2. Have you ever taken a course of study with an engineer?

3. Have you any mechanical experience?

4. State what experience you have had, especially in public work.

5. State any further experience that you may think important.

PRELIMINARY EXAMINATION, RAPID TRANSIT COMMISSION.

TECHNICAL PAPER.

NEW YORK, May 14, 1900.

Salary, $1 200.

1. Sketch a retaining wall, showing the angle of repose of earth. (*b*) Show the line bounding the prism of maximum pressure. (*c*) State the relation of the vertical angles bounded by those two lines. (*d*) Draw the diagram of forces acting upon the wall and state the position the resultant must take in order to insure stability.

2. (*a*) In what order do earths arrange themselves as to thrust, stating that with the least thrust first? (*b*) State the several conditions that will change the amount of thrust of earth.

3. (*a*) In the flow of water through channels and conduits, state the several causes of resistance to flow. (*b*) What is the principal cause of resistance to flow in long pipes?

4. What is meant by "mean hydraulic radius"?

5. (*a*) In a rectangular wall, at what point is the pressure of water applied? (*b*) How would you obtain the total pressure of water against the wall?

6. What is meant by "limit of elasticity" and what is the relation of the limit of elasticity to ultimate strength in steel and iron?

7. How will riveted joints fall in thin and thick steel and iron?

8. What is meant by the degree of a curve?

9. Having given the degree of a curve, how would you lay it out on the ground?

10. What instruments do you consider essential and desirable to make a survey of the subway?

11. What error would you expect in running levels a distance of a mile in a crowded street?

12. (*a*) How would you establish transit points? (*b*) State in this the establishing of transit points on block pavement?

13. If the line of the subway runs through several blocks and underneath the houses, how would you make a survey showing accurately the intersection of the line of the tunnel with all property lines?

14. What are the principal difficulties in making a survey through the city streets?

15. Show a specimen form of note-book for a survey of the subway under the streets through two blocks entirely built up.

Mathematical Paper.

1. Extract the square root of 10 873.2475.

2. What is the weight of a cast-iron column whose outside diameter is 12 in., thickness $\frac{3}{4}$ in. and length 13 ft. 6 in., allowing $11\frac{1}{2}\%$ additional for the base and cap?

3. A load of $70\frac{3}{8}$ tons is transmitted by an iron pedestal 3 ft. square upon a granite pier; the weight upon the earth under the pier shall not exceed 1 760 lb. per sq. ft.; the steps of the granite courses shall not exceed 1 ft.; the thickness of the courses is 2 ft.; what are the dimensions of the bottom course and what are the contents in cubic yards of the granite pier?

4. A train moving at the rate of 36 miles an hour is three-quarters of an hour ahead of another train moving at the rate of 42 miles an hour; in what length of time will the second train overtake the first?

5. A rectangle has an area of 60 sq. ft., its perimeter is 34 ft.; find the length of the sides.

Report Paper.

Write a report and specification for refilling the top of the subway in tunnel and paving the surface of the street with granite blocks.

PRELIMINARY EXAMINATION,
RAPID TRANSIT COMMISSION.

Technical Paper.

New York, May 19, 1900.

Salary, $1 200.

1. In a retaining wall with a load of earth filling, how far back from the wall will a load have no effect and why?

2. In what manner do retaining walls fail? State different conditions.

3. When trench for wall has been dug to right depth, what is the next step?

4. In formulas for flow of water in channels, how is fall in water surface taken account of?

5. In a tank filled with water, find stress in hoop 1 ft. from the bottom.

6. Sketch uniformly loaded beam. Show reaction of support in terms *W, L, D,* etc., and moment at center.

7. State distinction between long and short columns and state how each fails.

8. Two tangents to be joined by curve; show what field notes should be taken and how the elements of curve are determined.

9. Describe method of transferring line from surface through shaft to tunnel.

10. Describe best method of fixing center line and grade in tunnel.

11. Give sketch of record notes for survey for subway for location of center line and property lines through two built-up blocks.

12. How should the work be left at night on the end of a sewer under construction?

13. Sketch center of 20-ft. arch (dimensions approximate).

14. A heavily loaded column rests on a granite block, 18 in. by 18 in., this block being the top of a pier 3 ft. high resting on earth, pier to be stepped off in three steps 1 ft. in depth; how would you find the width of each step; give reasons?

15. Give precautions to be used in laying brick work when great strength is required.

RAPID TRANSIT COMMISSION. CLASS (B).

MAY 26TH, 1900.

Salary, $1 500.

1. Give age, technical education, and name of institution of which you are a graduate, if any, and name all positions you have held, with length of service and character of work.

2. Name all precaution for sighting a line in a tunnel and what is the best means of eliminating errors in prolonging a line in a tunnel?

3. What information beside center line and grade are necessary before starting work on a tunnel?

4. If center line runs under blocks of houses, what information is needed other than in above question?

5. How could filling of trench over arch affect the stability of the latter?

6. What would an inspector keep record of: (*a*) On tunnel work? (*b*) On elevated railroad structure?

7. What methods and precautions are necessary in excavating rock, including blasting and all details in vicinity of houses, and what when water pipes are present?

8. Give a sketch of sheet piling and timbering with all dimensions for trench 25 ft. deep for sewer, external diameter 4 ft.

9. State all conditions for securing best work in masonry construction (closeness of joints and pointing of blocks not meant).

10. (*a*) Give full description of operation of mixing concrete by hand. (*b*) Describe any mechanical mixer with which you are familiar.

11. Upon what does bearing power of piles depend; what precautions should be used in driving piles, and how would you find safe bearing power theoretically?

12. (*a*) How would you unite a new layer of concrete with old? (*b*) What is gained by storing Portland cement before using it?

13. Give safe bearing powers of: (*a*) Gravel. (*b*) Good clean sand. (*c*) Loam?

14. What is the condition of arch sliding at the springing and in what form of arch is this most likely to occur?

15. What condition of failure of rectangular wall is shown by (*a*) vertical cracks, (*b*) forward movement as a mass, (*c*) horizontal cracks and bulging? And what remedies would you use in each case?

16 to 20. Give report and careful sketch of design for foundation of subway, where ground is such as to require piles or timber construction. State the best means of controlling flow of quick-sand where such is encountered in trench. Give form for estimate of quantities and prices for each item.

RAPID TRANSIT COMMISSION. CLASS "C."

MAY 26TH, 1900.

Salary, $1 800.

1. Give date and place of graduation from technical college, if any; place, length and character of each important engagement since.

2. Under what conditions as to nearness of excavation, depth, character of soil, ètc., would you consider it necessary to underpin buildings on the line of subway?

3. Give essential features of process of underpinning a large water main so as not to interfere with its use.

4. Describe briefly operation of supporting and moving a large water main so as not to interfere with its use.

5. Describe alteration in line of a large brick sewer and method of caring for the flow meanwhile.

6. How would you arrange reports for your inspectors or other subordinates so as to obtain correctly the actual cost of any portion of the work?

7. Give an itemized example of this: (*a*) Ironwork, (*b*) stone masonry, (*c*) concrete.

8. Give all the points to be observed in the use of asphalt in water-proofing to insure compactness, freedom from blow-holes, thorough adhesion and sound work.

9. Describe the distinctive characteristics of foundations best adapted to the following sub-soil conditions: (*a*) Stiff gravel, (*b*) wet, soft mud becoming stiffer as depth increases, (*c*) soft mud with hard gravel 15 ft. beneath, (*d*) wet but confined and compact sand.

10. What are the advantages of a grillage of layers of steel rails set at right angles in concrete for a footing of a retaining wall? Show design for such a footing.

11. How would you provide for expansion and contraction in a long concrete retaining wall?

12. How many barrels of cement, yards of sand and tons of broken stone are required for 10 yd. of concrete of proportions 1, 3 and 5?

13. Give precautions to be taken for the health of assistants or laborers working under pneumatic pressure at a depth of 75 ft.

14. What is meant by "cut and cover" method in open cut construction and what is gained by it?

15. (*a*) What is the theoretical method of determining the safe bearing power of piles? (*b*) What modifications under different conditions? (*c*) Give practical method of determining the bearing power of piles.

16 to 20. Make a report and careful sketches of a proposed method for carrying the tunnel under the Harlem River. State what would be done in passing through different materials such as silt, clay or rock. Give itemized notes for estimate with approximate value of items.

ASSISTANT ENGINEER, RAPID TRANSIT.

Salary, $1 200. 1901.

1. Make a rough sketch of bracing, etc., in digging a double shaft 10 by 20 by 60 ft. deep. Give dimensions.

2. Make a sketch of a center for an arch with 20-ft. span, giving dimensions.

3. Describe the method of tunneling by shield.

4. Also by blasting.

5. Describe the method of triangulation to locate a tunnel, as East River tunnel and approach.

6. What are the principal requirements in relaying an asphalt pavement?

7. In relaying block pavement?

8. What is done with water in a tunnel below the level of a sewer?

9. How would you get a sight in a tunnel?

10. (*a*) How is a line prolonged accurately? (*b*) How is an angle turned accurately?

11. What are the requirements for substantial stone masonry?

12. Under what conditions can wood be used in permanent constructions?

13. Where and how would you locate a bench mark and point in a tunnel?

14. If a brick sewer is to be replaced by a number of cast-iron pipes so as to pass under a subway, how are their size and number determined?

15. What do the specifications call for in regard to the storing of material?

ASSISTANT ENGINEER, GRADE "A."

DECEMBER 8TH, 1902.

Salary, $1 200.

1. How would you lay out work for subway trench when work is in open cut?

2. (*a*) How would you give grade and line in tunnel? (*b*) How would you proceed when artificial light is used?

3. Give force and material account for keeping track of work from day to day.

4. How would you determine spacing of iron bents on curve?

5. When water is being pumped from beneath foundations, how would you determine whether or not settlement is likely to occur?

6. How would the engineer proceed to inspect roof of a rock tunnel after a blast?

7. A single large sewer is replaced by three smaller ones; is it sufficient to make new area equal to old? Explain fully.

8. Sketch a timber center for semi-circular brick arch, 25-ft. span.

9. Give quick rough test for cement in field, without the use of machine.

10. What are the requirements for good work in building a brick sewer?

11. How would you inspect a job of riveting?

12. For driving piles in quicksand, is it better to use quick, light blows, or slow, heavy ones? Explain reasons.

13. In back filling trench, what is the best arrangement of shovelers and rammers to get the best results?

14. How is work in tunnel conducted? (New York Subway.)

15. Write a careful report on a pile foundation and masonry pier for a bridge.

MATHEMATICS.

1. Extract square root of 30 001.94.

2. Four numbers whose sum equals 900; the first plus 2, the second minus 2, two times the third, and the fourth divided by 2, are equal. What are the numbers?

3. A trapezoidal field; parallel sides 18 ft. and 28 ft. The perpendicular distance between them is 42 ft. How far from the longer parallel side is a line dividing the field into two parts of equal area?

4. Two numbers whose sum is 6. The sum of their fifth powers is 1 056. What are the numbers?

ASSISTANT ENGINEER.

Salary, $1 200. April, 1903.

1. As applying to Rapid Transit Railroad construction, describe how you would transfer a bench mark from a point 200 ft. off the line to and down a tunnel shaft to a point 400 ft. within the tunnel.

2. The same for a transfer of a transit line to a P. C. in the tunnel.

3. Show by a sketch and describe a typical vertical section of a double track tunnel where it is necessary to keep close to the surface, including important dimensions and indications of materials used.

4. Show by plan and horizontal cross-section just above the track (double) the arrangement of answer to (3) assuming curve to a tangent at right angle.

5. State or show by sketch why side clearances on curves in tunnels must be greater than on tangents and calculate how much for a 60-ft. car with 40-ft. center to center of trucks.

6. Describe how the standard railroad track is best maintained in line and grade.

7. Describe "damp proofing" and its method of application.

8. Describe the method of transmission of electrical power by a third rail. State its advantages and disadvantages. (*b*) What are the important details of mixing and laying concrete to secure good work? (This does not refer to proportions of material.)

9. Assume data you consider reasonable and determine the external pressure on a steel tunnel tube 12 ft. in diameter running beneath 100 ft. of water, supported above bottom.

10. Outline specifications for stone and laying of first-class ashlar granite masonry in a heavy retaining wall.

11. State what you know of concrete steel and its advantages.

12. How is condensation prevented on roofs and station walls?

13. State everything necessary to secure the best cement mortar joints in brickwork, such as important sewer construction.

14. Show by sketch and description the method of sheeting a tunnel shaft (vertical) 12 ft. wide, 60 ft. deep throughout.

15. Write a report of not less than three nor more than four pages concerning the examination and method of shoring and placing in a sound condition a building which had partly settled due to excavation of R. T. tunnel.

Report.

Write a report of not less than two nor more than three pages on the probable causes of cracking of the roof and settling of the sidewalks of a tunnel (subway).

Mathematics.

1. Extract square root to four decimals of 629,514,455.084.

2. The center line of a portion of a circular street subtends an angle of 30° at the center, the raidus being 530. If the street is 60 ft. wide, find the area in square yards of the portion of the street.

3. Add the following, giving the answer in feet and decimals:

$$6'-7\tfrac{1}{2}'';\ 7'-3\tfrac{3}{16}'';\ 8'-2\tfrac{13}{31}'';\ 11-7\tfrac{1}{8}'';\ 21-11\tfrac{9}{16}'';\ 0'-6.5'';$$
$$12'-7''.35.$$

4. Find the volume of masonry in the roof of a tunnel 2 ft. thick with a semi-elliptical section with radii of 36 ft. and 20 ft., the portion being 100 ft. long.

ASSISTANT ENGINEER, RAPID TRANSIT COMMISSION.

JUNE 8, 1904.

Salary, $1 200.

1. What are the precautions necessary to accurately measure a line, such as a base line for a triangulation survey?

2. What are the important points to be observed by a leveler in doing accurate leveling?

3. Same for a rodman.

4. State in their order the adjustments of a transit which also has an attached bubble for leveling.

5. Except for base line measurements, describe how an important triangulation would be done across the East River for the purposes of tunnel construction.

6. In designing of coursed ashlar masonry retaining walls, state briefly the theory of pressure and the methods of calculation.

7. In the construction of the same, state the precautions necessary to minimize the pressure and to secure sound and permanent work.

8. In concrete work, what are the important points: (*a*) in fixing the proportions; (*b*) in mixing; (*c*) in placing—all for high-class work.

9. Outline briefly the principles involved in the reinforcement of concrete-steel.

10. Show by sketch, with dimensions, a pile foundation for heavy masonry walls.

11. Describe briefly a good roadbed and track construction suitable for Rapid Transit subway.

12. State the prismoidal formula and illustrate its use by cross-section of an earth railroad embankment.

13. Show a monthly contractor's estimate covering open cut earth and rock excavation, concrete footing, brick masonry, steel built columns and beams; use approximate ruling prices.

14. Describe the method of tunnel construction in gravel and clay 50 ft. below water level.

15. Show by sketches, giving general dimensions and size, the method of construction of the lumber work of a double tunnel shaft 8 by 20 ft. and 60 ft. deep, in earth.

Report.

Write a report of not less than two nor more than three pages on the probable cracking of the roof and settling of the side walls of a tunnel.

PROMOTION EXAMINATION FOR ASSISTANT ENGINEER OF THE RAPID TRANSIT COMMISSION.

DECEMBER 14, 1905.

Salary, $1 200.

1. Transfer center line from surface to bottom of shaft 15 ft. wide, 20 ft. deep.

2. In measuring a long distance with a 100-ft. tape, what five precautions are necessary to get accurate work?

3. Subway running through street where two-track surface road and elevated structure are located. How will you support the street and "L" columns so as not to interrupt traffic on road; "L" columns set on curb 6 ft. inside of retaining walls of subway.

4. What is the relation between two rails on a transverse section of track on curve? Give reasons.

5. The subway crosses a 10-ft. circular sewer with a 0.5% grade, the sub-grade of subway 2 ft. above invert of sewer. How would you provide for sewerage without diminishing capacity?

6. What is the relation between velocities in circular pipes full, nine-tenths full, one-half full, one-quarter full?

7. What precautions would you take in blasting rock in open trench for the protection of adjoining property and persons?

8. What precautions should be taken in mixing and placing concrete (*a*) in ordinary foundation, (*b*) reinforced concrete arch, (*c*) when concrete is mixed with temperature below 30° Fahr.?

9. What precautions should be taken when assembling steel to make a good job?

10. How would you set stone bases for columns and what precautions?

11. How would you set granite block pavement on concrete base?

12. How would you prepare concrete for asphalt and what special precautions should be taken?

13. Figure thickness for a steel pipe 300 lb. pressure, 24 in. diameter, steel at 60 000 lb., factor of safety, five.

14. In back filling trench, what precautions are necessary to prevent or minimize future settling?

15. How would you prepare metal for painting and in what condition of weather should paint not be applied?

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IN THE

CIVIL SERVICE OF THE CITY OF NEW YORK

TYPICAL QUESTIONS AND ANSWERS

ASSISTANT ENGINEER, RAPID TRANSIT COMMISSION.

TYPICAL QUESTIONS AND ANSWERS.

1. What is the best way to fix the center line in tunnel?

Where the tunnel is in rock, by drilling holes in the roof and driving wooden or metal plugs provided with hooks, from which plumb bobs are suspended. Where timber bents are required to support the roof, nails or hooks may be driven in the timbers to fix the center line.

2. How would you carry the center line down a shaft and into tunnel? Explain every step and everything required.

The center line is first run on the surface, points being set very accurately, and repeatedly checked on both sides of the shafts. These points should be of permanent character. Horizontal cleats are fastened to the shaft timbers and the center line marked on them. Heavy plumb bobs weighing about 35 lb. are suspended from these points by fine piano wires. The bobs are steadied by being immersed in oil. The distance between these wires should be as large as the shaft will permit.

Set up transit in tunnel accurately on line with these two suspended wires and prolong the line, setting points ahead or behind as required, "double centering" with the instrument.

3. (*a*) When in tunnel how would you establish lines and grades? (*b*) How would you prolong the same where artificial light is required?

(*a*) Center lines are established in the roof of the tunnel as described in Question No. 1; sometimes in the bottom (where conditions permit).

Grades are established by marking points on the side walls or on ledges a whole number of feet above the grade of the tunnel.

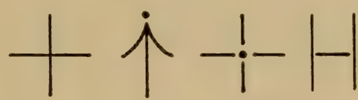
(See also Q. No. 6.)

(*b*) Where artificial light is required, the sights and instrument are illuminated with a candle, lamp or electric light provided for the purpose, the ordinary method of prolonging lines being used.

Special sights with illuminated slits set accurately on line may be used for alignment.

4. How would you mark center line of tunnel? (*a*) In open field, (*b*) on block pavement, (*c*) on asphalt pavement, (*d*) on rock, (*e*) in tunnel.

(*a*) By means of large hardwood stakes driven firmly in ground, line being marked by tacks. If the center line falls on exposed rock surfaces, suitable marks are cut in same, such as + ↑ -¦- H. Stone



monuments or concrete blocks with copper bolts should be set about every half mile.

(*b*) On block pavement, cut marks on the blocks as indicated above, or drive spikes in the joints, or blocks may be removed and spikes or stakes driven in foundation and recovered.

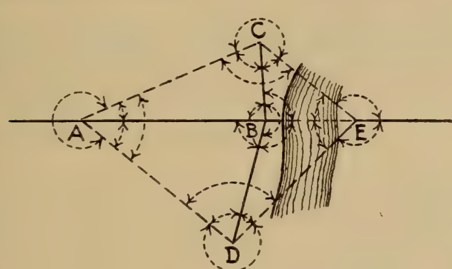
(*c*) Drive spikes through the asphalt or remove section of asphalt, drive stake underneath and replace with brick or loose material.

(*d*) By marks as designated in (*a*) or by metal plugs set in holes drilled in the rock.

(*e*) For marking center line in tunnel see Question No. 1.

5. How could you carry the center line of tunnel (*a*) across the East River, (*b*) down a shaft and into tunnel?

By triangulation as follows:



A B is portion of center line already established on one side of river.

Prolong line to *E* on opposite shore by double centering, making several trials. This fixes a point on line on the opposite shore.

The stationing of this point is obtained by triangulation. (See diagram.) The distance, *A B*, is accurately known. *C* and *D* are selected to give well conditioned triangles.

Read the angles as shown by the arrows. Calculate *B C* and *B D* and then *B E*, from which the stationing of *E* is obtained. The line is then prolonged from *E* in the usual manner.

(*b*) See Question No. 2.

6. Where and how would you locate the bench mark in a tunnel?

In rock tunnels bench marks should be located on ledges in the side walls, where they can be seen from both directions and not apt to be disturbed by the tunnel operations.

In earth tunnels, or in rock tunnels where timber is used to support the roof, spikes are driven near the foot of the most rigid posts, observing that the rod can be held vertically on same and that the rod can be seen from both directions. They should be well marked and described for identification.

7. As applying to Rapid Transit subway construction, describe how you would transfer a bench mark from a point 200 ft. off the line to and down a tunnel shaft to a point 400 ft. within the tunnel.

First transfer the bench mark to a point on one of the shaft timbers at the surface. With the aid of a steel tape, this bench mark is transferred to the bottom of the shaft at a point vertically beneath, the bottom being prepared for the purpose. This tape measurement should be repeated several times and the mean taken, thousandths being estimated. Using this new point as a bench mark, the levels are run in the usual manner, establishing bench marks as conditions require. Artificial light should be employed if necessary.

8. The same for the transfer of a transit line to a P. C. in tunnel.

Transfer the tangent from the surface to the tunnel as described in Question No. 2. The stations at the points of suspension of the bobs should be very accurately determined and this stationing applied to the points vertically beneath at the bottom of the shaft. The P. C. is then located in the usual way from the points thus established.

9. Besides the location of property lines and center line, explain what a complete examination of the tunnel route should consist of, especially under buildings and where tunnel crosses a stream.

The examination should show the character of the material along the route of the tunnel, whether rock, earth, made land, etc., as determined by numerous borings; all underground obstructions, such as sewers, water and gas mains, electric conduits, etc.; character of pavements; nature and extent and depth of building foundations and the underlying material; the character of the buildings, their height and construction. Understreams, the examination should show high and low water range, the depth at the bottom, the character of the material in the bed of the stream to prescribed depths, determined by borings.

10. When the rapid transit road is to be in open cut, how would you lay out the work previous to beginning the excavation?

Run an offset line, preferably parallel to the center line of the tunnel. This offset line should be outside of the neat lines of the excavation and where not likely to be disturbed by the work.

Offsets to the center line, from the house line, the curb line, or from the offset line itself, are marked on the face of the curb, sidewalk or other suitable place for the guidance of the foremen, as also the depth of cut to subgrade of excavation.

11. Where two tangents are to be joined by a curve, state what field notes are taken and generally what elements of curve are found?

Notes taken:
Bearing of tangents.
Angle of intersection of tangents.
Sta. at P. I.
Stations occupied by instrument.
The following elements of the curve are found:
Degree of curve.
Radius of curve.
Length of curve.
Deflection angles.
Tangent distances.
Stas. of P. T. and P. C.

12. What is the difference between "refraction" and "reflection" as applied to light, and how does the former affect the line of sight taken through a level?

See Leveler. Vol. I, Part III.

13. Suppose you had in leveling to take 1 600 ft. sights; how can you do it with reasonable accuracy and eliminate effects of curvature and refraction?

By taking equal back and foresights and repeating and averaging rod readings.

14. Why is not running the lines by the magnetic needle an accurate method?

Because the graduations on compass box are not adapted for accurate reading, and because local attraction and magnetic disturbances affect the needle.

15. What is the reason, if any, for taking the magnetic bearing of lines in making a survey?

As a check on the angles measured between courses of the survey.

16. What is the method for calculating areas from traverses?

Compute the double meridian distances of the courses and multiply them by their respective latitudes. Take the algebraic sum of these products and divide by two.

17. What is the greatest allowable error in precise leveling 4 miles?

About .05.

18. What is a fair closure of 20 angles in a traverse?

One minute.

19. What is your method of calculating earthwork?

For ordinary calculations use the average end area method. This consists of computing areas of cross-sections taken at suitable stations, averaging these areas successively, multiplying by their corresponding distances apart, and adding the products.

20. Give the safe bearing power of gravel, good, clean sand, loam, clay, hardpan, rock.

Gravel	5	tons per sq. ft.
Good, clean sand	4	" " " "
Loam	1	" " " "
Dry clay	3	" " " "
Wet clay	2	" " " "
Hardpan	8	" " " "
Rock in ledges	36	" " " "
Rock in beds	240	" " " "

21. (*a*) In what order do earths arrange themselves as to thrust, stating that with the least thrust first? (*b*) State the several conditions that will change the amount of thrust of earth.

(*a*) (1) Compact gravel, (2) dry clay, (3) moist earth, (4) dry sand, (5) wet clay.

(*b*) Earth thrust will be changed by presence of water in backing, vibration and jar due to traffic, superimposed loads on earth backing, frost, settlement and manner of depositing the backing.

22. In taking loamy earth from a borrow pit, what difference in cubical contents will there be between the borrow pit and the complete fill?

About 12 per cent.

23. What is meant by "limit of elasticity," and what is the relation of the limit of elasticity to ultimate strength in steel and iron?

The limit of elasticity is the point up to which the strain of the material is proportional to the applied stress. Any additional stress

will produce permanent deformation. *In steel and iron the elastic limit is about one-half the ultimate strength.*

24. How will riveted joints fall in thin and thick steel plates?

In thin plates failure may take place by:
1. Shearing of plate.
2. Crushing of metal about rivets.
3. Shearing of rivets.

In thick plates:
1. Shearing of rivets.
2. Bending of rivets.

25. Under what conditions can wood be used in permanent construction?

It can be used for work under water. It must not be exposed to the air at any time. It must also be protected from the teredo or other destructive forms of aquatic life.

26. What is hydraulic cement and what are its properties and uses as regards engineering construction? Outline briefly the methods by which you would test the relative merits of two or more samples.

Cement which possesses the property of hardening under water is called hydraulic cement. Hydraulic cement sets slowly and attains great strength. It resists the action of the weather. It is made of a mixture of lime and clay, natural or artificial, pulverized and burnt to vitrification.

Its main properties are that it sets in air or in water and attains great strength which increases with time. It is used as a cementing material in masonry structures and in the manufacture of artificial stone, concrete, etc.

27. What are the physical differences between American Portland and Rosendale cements? How are they manufactured?

Physical Differences.

Portland Cement.	*Rosendale Cement.*
Texture—Close, floury.	Porous and globular.
Color—Bluish and greenish gray.	Brownish.
Slower setting than Rosendale.	Sets quickly in air. Hardens slowly in water.
Spec. Gr. 3.0. ±	Spec. Gr. 2.7.
Weight, 86 lb. per cu. ft.	Weight, 50 lb. ±per cu. ft.
Stronger than Rosendale.	Not as strong as Portland.

In the manufacture of Portland cement lime rock and cement rock are quarried separately, ground and mixed and then burned to incipient vitrification. The clinker is then crushed and pulverized and bagged for the market.

Rosendale cements are manufactured in a similar manner, only that the raw material is a natural mixture of the lime and cement rock.

28. How do you test cements?

Cements are tested to determine their
1. Fineness.
2. Setting.
3. Soundness.
4. Specific gravity.
5. Strength.

1. Fineness is determined by passing the cement through sieves of various meshes and noting the percentages retained.

2. Setting is determined by making pats of the cement and noting the time before they resist penetration of wires of specified weight.

3. Soundness is tested by noting the condition of the edges of the pats; also by heating pats with steam and seeing if they blow or crack.

4. Specific gravity is determined by apparatus provided for the purpose.

5. Strength is determined by preparing briquettes and permitting them to remain in air and under water specified periods, and then breaking them in a testing machine and noting the breaking load.

29. What are the important details of mixing and laying concrete to secure good work? (This does not refer to proportions of materials.)

Mixing boxes should be provided for the sand, cement and stone. The sand and stone must be clean and free from dust. The sand and cement should be thoroughly mixed dry, the proper amount of water added, and then the stone incorporated in the mortar.

The material should be deposited immediately after mixing in 8 or 12-in. layers and well rammed.

The forms should be firm, unyielding, smooth on the inside, and have tight joints.

The forms should be allowed to remain for 12 hours after laying.

Mortar or concrete partially set should not be tempered or used.

Work should not be done in freezing weather, and in warm weather concrete should be kept moist and protected from sun. When

new work is to be laid on old work, the old work should be thoroughly cleaned and painted with neat cement.

The work should be protected from traffic until thoroughly set. All exposed surfaces should be neatly pointed.

30. Give (*a*) full description of operation of mixing concrete by hand. (*b*) Describe any mechanical mixer with which you are familiar.

(*a*) See Question No. 29.

(*b*) For descriptions of mechanical mixers see trade catalogues, which can be obtained from manufacturers.

31. What are the objections to tempering concrete? (*a*) Why are masses of concrete left wet for several days? (*b*) Why do you mix broken stone and gravel wet? (*c*) Why do you not use the shovel in laying concrete? (*d*) When is concrete cheaper than brick?

Tempering concrete weakens it greatly. The concrete has already partially set and tempering disturbs the chemical action which has begun, reducing the tensile strength.

(*a*) Evaporation, percolation, and absorption by the stones cause a large loss of water in the mass of concrete and thus deprives it of the necessary water required for proper setting. In order to avoid this, the mass of concrete is kept wet.

(*b*) Broken stone and gravel are mixed wet, as they absorb water from the mortar and would therefore retard and interfere with its setting.

(*c*) If a shovel is used in laying concrete the mortar sticks to the shovel and will thus be separated from the stone; the water will run off the shovel, carrying the lightest material with it. This will be the case especially where the fall is considerable.

(*d*) Concrete is cheaper than brick when used in large masses and where expensive and elaborate forms are not required.

32. (*a*) How would you unite a new layer of concrete with old? (*b*) What is gained by storing Portland cement before using it?

(*a*) By thoroughly washing and scrubbing the surface of the old concrete and painting the surface with neat cement or a rich mortar before the new concrete is laid. It is claimed by some that the use of tempered concrete at junction of old and new work will give good results.

(*b*) Fresh cement contains free lime which causes expansion or "blowing" and might endanger the structure in which it is used in this condition. During the time of storing the free lime is changed to carbonate of lime and in this state the cement does not swell.

33. Describe briefly rubble masonry, ashlar masonry, and state the classes of engineering structures for which these, and also brick masonry and concrete, are each adapted.

Rubble masonry is composed of rough, undressed stone; it may be coursed, uncoursed or cobweb; used for cheap retaining walls, foundations of buildings, piers and abutments of highway bridges, and the backing of walls, dams, etc.

Ashlar masonry is composed of cut stone, either coursed or random, laid in close joints. It is used for first-class retaining walls, piers of railroad and highway bridges, and facework of dams, abutments, anchorages, arches, etc.

Brick masonry is used largely for walls and piers of buildings, for column footings, for sewers, arches of small span, etc.

Concrete masonry is adapted for all classes of engineering structures; especially adapted for underwater structures, such as pier foundations, etc.

34. State briefly what you know of concrete-steel construction and its advantages.

Concrete steel construction consists of steel imbedded in concrete so that the structure may act as a unit in resisting any strains that may come upon it. The steel is designed to take all the tension and the concrete the compression. Its application is universal, being used for the abutments and piers of bridges, arches, foundations, buildings, etc. Advantages: It is economical, durable, its elements easily transported, and it can be adapted to a variety of conditions.

35. How many barrels of cement, yards of sand, and tons of broken stone are required to make 10 yd. of concrete of proportions 1, 3 and 5?

Assume voids in cement = 0.
" " sand = 30%
" " stone = 40%

1 batch of concrete, proportions 1, 3, 5, will contain

1 bbl. = 3.7 cu. ft. cement
3 " = 11.1 " " sand
5 " = 18.5 " " stone

3.7 cu. ft. cement,	with	0%	voids,	gives	3.70 cu. ft. in concrete.
11.1 " " sand,	"	30%	"	"	7.77 " " " "
18.5 " " stone,	"	40%	"	"	11.10 " " " "
Each batch contains.............					22.57 " " " "

For 10 cu. yd. of concrete there will be required $\frac{10 \times 27}{22.57} = \frac{270}{22.57}$ = 11.9 batches, say 12 batches.

There will be required, therefore,

$3.7 \times 12 = 12$ bbl. cement

$\frac{11.1 \times 12}{27} = 4.93$ cu. yd. sand

$18.5 \times 12 = 222$ cu. ft. stone = about 22 200 lb. = 11 tons ±

36. What are the requirements for substantial stone masonry?

Substantial stone masonry must fulfill the following requirements:

The stone should be hard, sound, durable, cleaned and wet before laying.

The cement must be of A1 quality.

The sand must be clean, sharp, and free from loam.

In mixing the mortar care should be taken that it is done thoroughly, not in freezing weather; that the proper amount of water is used. In laying the masonry, all joints should be full of mortar, as few spawls as possible to be used. Courses should be well bonded. Stones must be properly bedded on natural beds. Joints must not exceed limits prescribed. All exposed face joints should be well pointed.

37. Give precautions in laying bricks where great strength is required.

The bricks should be thoroughly wetted just before laying. Every brick must be completely imbedded on mortar under its bottom, on its sides and on its ends at one operation. Every joint must be full of mortar. The joints must be close, not exceeding ¼ in., and pointed. Unfinished work must be racked or toothed. Before new work is added, the old work must be cleaned thoroughly and well moistened. The work should be well bonded.

38. Describe a quick, rough test for cement that can be made on the work without machine.

Make a small pat of neat cement and note interval of time elapsed until it resists slight pressure of thumb nail. Also note, after the cement is set, if the edges of the pat show cracks.

A ball 1 in. in diameter of neat cement is often made (by mixing with a little water) and allowed to set. It should not crack or crumble, but grow steadily harder.

39. Describe the requirements of good work in building a brick sewer.

The bricks shall be best quality, hard burned, free from cracks, and have true, even faces.

They must be thoroughly wet before laying.

Each brick must be laid in full mortar joints on bottom, sides and ends, which must be performed in one operation for each joint.

No mortar to be worked in after brick is laid.

Joints not more than $\frac{3}{8}$ in. in thickness.

Brickwork should be properly bonded and arches keyed.

Hydraulic cement should be used.

Cement and sand should be of proper quality and properly mixed.

The mortar should be used right after mixing; no mortar which has begun to set should be used.

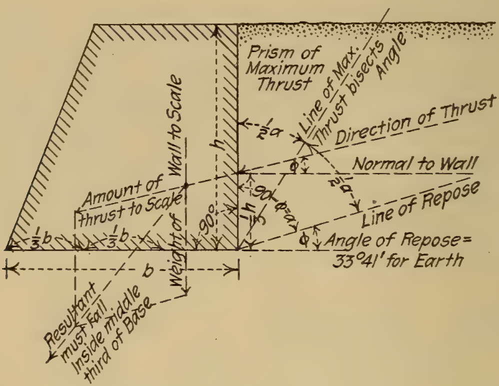
No work should be done in freezing weather.

Every second course should be laid with a line.

The foundation must be firm and unyielding.

Centers must be of proper form and dimensions, and proper care observed in "striking" same.

40. (*a*) Sketch a retaining wall showing the angle of repose of earth. (*b*) Show the line bounding the prism of maximum pressure. (*c*) Show the relation of the vertical angles bounded by these two lines. (*d*) Draw the diagram of forces acting upon the wall and show the position the resultant must take in order to insure stability.



41. In what way do retaining walls fail and why?

1. By overturning about the toe, owing to the insufficient thickness of the base of the wall.

2. By bulging or sliding due to the *excess* of the horizontal thrust produced by the backing, over the frictional resistance of the joints.

3. By crushing of the masonry due to its poor quality, to excess of unit pressure, or both.

4. By disintegration of the wall, caused by soft, yielding foundations, heaving and unequal settlement, or improper drainage of the backing.

42. What condition of failure of a rectangular wall is shown by (*a*) vertical cracks, (*b*) forward movement as a mass, (*c*) horizontal cracks and bulging. What remedies would you use in each case?

(*a*) Shows unequal settlement, remedied by increasing thickness of wall.

(*b*) Due to sliding of wall on its foundation; remedied by using land ties or building buttresses on the front face of the wall, also by shoring up the wall.

(*c*) Occurs in thin walls where the insufficient weight of masonry above a joint permits sliding. In this case the horizontal component of thrust against the wall is greater than the frictional resistances of the joint surface; remedied by increasing the thickness of wall.

43. If the backing of a retaining wall is very wet mud, how would you investigate the stability, not considering sliding?

In this case use the weight of the wet mud instead of dry earth and the corresponding friction angle in the calculations; or the wet mud may be considered as exerting purely hydrostatic pressure with thrust normal to the back of the wall.

44. Suppose the earth behind the wall is liable to be very wet at times, may any method be employed to reduce danger to the wall?

Yes. Weep holes should be left at intervals in the wall to carry off the water. Drains built along the wall and having a proper outlet will accomplish the same purpose. The backing adjacent to the wall should be of loose material, such as broken stone or gravel.

45. How would you provide for expansion and contraction in a long concrete retaining wall?

At intervals of 50 ft. or more openings are left about ½ in. wide, running the entire depth of wall, this space being filled with sand, asphalt or paper to retain backing. Steel rods may be imbedded to reduce effect of temperature changes.

46. Upon what does bearing power of piles depend and what precautions should be used in driving piles, and how would you find safe bearing power theoretically?

The bearing power of piles depends upon the skin friction or surface friction of pile and the point resistance; the former varying with size of pile and character of the material; the latter varying with the resistant character of stratum upon which pile rests. In driving piles, care should be taken to prevent "brooming" of head. A hoop or cap of iron may be used for this purpose. Excessive ham-

mering on pile that refuses to move should be avoided. Piles should be driven straight and to proper depth, with a proper fall of ram or hammer. Safe bearing power in pounds

$$= \frac{2\ w\ h}{s + 1} \text{ in which}$$

w = weight of hammer in pounds.
h = fall in feet.
s = penetration of last blow in inches.
This gives safety factor of 6.

47. How would you tell when a pile has been driven sufficiently?

When a number of successive blows produces a penetration equal to or less than amount prescribed by specifications. The load on the pile being known, the penetration may be calculated from formula. See Question 46. Test loads may be applied.

48. What effect, if any, has the brooming of a pile upon the effect of the hammer in driving it?

A "broomed" head acts as a cushion and dissipates the blow of the hammer.

49. Outline briefly the essential points to be covered in specifications for timber piles and pile driving.

The specifications should describe the kind of timber, such as oak, pine, etc. The pile shall not be less than 8 in. nor more than 12 in. at small end, and not less than 12 in. at large end. The timber shall be free from shakes and defects. The piles shall be pointed before driving. They shall be straight, and bark removed. Only portions left in work will be paid for. The top shall be banded before driving. The broomed portions shall be cut off. Iron shoes must be provided if necessary. The weight and fall of hammer and the penetration of the last blows shall be specified.

50. Describe the distinctive characteristics of foundations best adapted to the following sub-soil conditions:

(*a*) Stiff gravel.
(*b*) Wet, soft mud becoming stiffer as depth increases.
(*c*) Soft mud with hard gravel 15 ft. beneath.
(*d*) Wet but confined and compact sand.

(*a*) Excavate to the required depth; smooth the bottom and spread a layer of concrete over the foundation.

(*b*) Drive piles to proper bearing, cut the piles off level, build a timber grillage platform and place concrete on it, or cap the piles and surround with concrete.

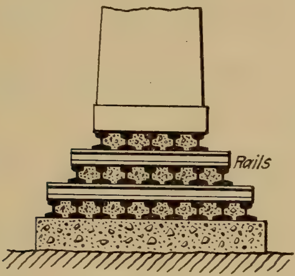
(*c*) Build a coffer-dam or sheath the outside of foundation; ex-

cavate the gravel, prepare bottom and deposit concrete, or proceed as in case of soft mud (*b*).

(*d*) Deposit concrete on the prepared bed of sand, confining sand.

51. What are the advantages of a grillage of layers of steel rails set at right angles in concrete, for a footing of a retaining wall? Show design for such a footing.

The grillage causes a uniform distribution of the load over the foundation, thus reducing the unit loads to safe limits.



52. How would you construct an earthen dam on gravelly soil so as to insure tightness?

Excavate to proper depth specified. Clean the bottom of all perishable material. If springs are encountered lead them off or tap them. Drive several rows of tongued and grooved sheet piling for cut off of water. Construct the center portion of puddle, the up-stream portion of fine material and the down-stream of coarse material, bonding the three portions well together. The up-stream slope about 2 to 1 and the down-stream about $2\frac{1}{2}$ to 1. Pave the upper slope and sod the lower. Material should be deposited in layers, watered and rolled.

The necessary provisions for intakes, gates, overflows, etc., should be made.

53. Give method of obtaining size of whaling pieces and size and distance apart of struts.

The pressure or thrust on a whaling piece depends:

1. Upon its depth from the surface.
2. Upon distance between centers of whaling pieces.
3. Upon distance between centers of struts.
4. Upon the character of retained material.

The whaling pieces are considered beams uniformly loaded, whose spans equal the distances between centers of horizontal struts, each whaling piece supporting the earth half way to the next whalings above and below. The unit pressure at the depth of the center of

whaling piece times the supported area gives the load, and the size is computed by the beam formula.

When the size of the whaling pieces becomes too large the span is reduced by placing the struts nearer together. The size of the struts is obtained by the column formula, the load being that on half of each adjoining whaling piece, and the length, the width of the trench.

54. (*a*) How do circular arches generally fail; (*b*) segmental arches; (*c*) flat arches or 2 or 5-center arches?

The failure of most arches is due to unequal settlement.

(*a*) If the rise is less than the span the arch generally fails by the spreading of the haunches and the sinking of the crown. If the rise is more than the span, the haunches will generally be pressed inward and the crown will rise.

(*b* and *c*) For flat, segmental, or 2 and 5 centered arches, failure occurs usually by spreading of the haunches and sinking of the crown.

55. Define line of thrust, and in designing an arch where should it fall?

Line of thrust is the line of the resultant pressure due to dead and live load on arch. In designing an arch this line should fall within middle third of any joint.

56. How would you design the base of abutment of arch?

$$\frac{\text{The radius of arch in feet}}{5} + \frac{\text{rise in feet}}{5} + 2 \text{ feet}$$

$=$ with of abutment in feet (at springing line).

The base is obtained by adding to this the additional width due to the batter.

57. (*a*) Describe the method of tunneling by shield, (*b*) by blasting.

(*a*) Shafts are driven at suitable points as at shore ends of a river, of sufficient size to permit lowering of shield, or the shield is erected in temporarily enlarged section of tunnel. A compressed air plant furnishes the air supply at required pressure to prosecute the work. Hydraulic jacks or rams force the shield ahead, the material filling the compartments of the shield being excavated by the men in same, through the bulkhead doors in shield diaphragm, and removed in cars to the shaft and out. The jacks bear against the finished lining of tunnel, which is carried ahead as shield progresses.

(*b*) See Question No. 58.

58. Describe the operation of tunneling for the work through rock.

After the shaft has been sunk to sub-grade, a heading, about 6 ft. square, is driven near the crown of the arch of the tunnel section. The drill holes are driven about 9 ft. in, and converging, so that the blast will remove a conical-shaped mass of rock. The sides are then taken out to the lines of the tunnel section. Following this, holes are drilled in the shelf or bench thus formed, the heading meanwhile being carried forward. Care should be taken in blasting that sides and roofs outside of tunnel lines are not disturbed, and that adjoining property is not endangered. Loose or disintegrated rock outside of tunnel lines should be removed. After each blast the rock or spoil is removed to the surface. Water-bearing seams should be drained or grouted.

59. After a blast has been made in tunneling, how would you examine the roof to see whether the rock was safe or so shattered as to be in danger of falling?

The roof, after being carefully inspected, is sounded or tapped with a long pole or rod, loose rock being readily located by the sound. Precaution must be taken in sounding against the danger of falling rock, the examiner standing to one side.

60. What methods and precautions are necessary in excavating rock, including blasting and all details in vicinity of houses, and what, when water pipes are present?

The contractor should comply with all ordinances of the city. Before a blast is fired the rock should be covered with mats and logs. The prescribed explosives should be used in small charges.

In residential districts blasts should not be fired between 8 P. M. and 7 A. M. No more explosives than is needed for 12 hours should be stored at one time on the work. It should be divided as much as possible and kept under lock and key, and separated from caps and exploders. Near water pipes rock within 5 ft. should be removed by hand.

61. Give precautions to be taken for the health of assistants or laborers working under pneumatic pressure at a depth of 75 ft.

Proper ventilation should be maintained. Carbonic acid gas not to exceed one-tenth of 1%. Noise-deadening devices should be used. Fumes from blasts must be rapidly removed. Ample locks of approved pattern must be provided. Suitable quarters should be provided near the shaft where men can wash, bathe, change clothing, be warmed on coming out of compressed air. Hot coffee should be obtainable at all times and physician must be in attendance. A compressed air hospital lock should be provided in case men are attacked by caisson disease.

62. What is meant by "cut and cover" method in open cut construction and what is gained by it?

The "cut and cover" method consists of excavating part or the whole tunnel section, building the side walls and covering the tunnel as soon as possible. It is used in city streets where the depth is not great enough to warrant tunneling. The object is to prevent as much as possible interference with traffic.

63. What is meant by (*a*) cut and cover, (*b*) ashlar, (*c*) three-centered arch, (*d*) sump?

(*a*) See Question No. 62.

(*b*) Ashlar refers to masonry composed of cut stones or blocks and laid in close joints.

(*c*) A three-centered arch is an arch composed of three arcs having three different centers, but only two different radii.

(*d*) A sump is a depression or well in low point of excavation into which all drainage is led and from which it is pumped.

64. What is done with water in a tunnel below the level of a sewer?

The water is drained into sumps at convenient points, such as stations, and discharged by automatic ejectors or pumps into the sewers.

65. In back-filling a trench, what is the arrangement of shovelers and rammers so that there shall be no subsequent settlement?

There should be three or four rammers to each shoveler, the ramming proceeding at the same time with the shoveling. The material is back-filled in layers and flushed.

66. When a trench for a wall has been made to the right depth in any kind of earth, what is the next step?

In earth objectionable material should be removed and replaced with good, firm earth. The bottom of the trench is then leveled off to an even surface, flushed and rammed. The footing courses are then laid. In rock the bottom is cleaned, stripped of disintegrated portions and stepped off. The masonry is then started.

67. (*a*) When is sheet piling left in? (*b*) When is it tongued and grooved?

(*a*) When careful drawing of same is apt to disturb retained material and thus endanger the foundations of adjacent structures.

Also when the cost of drawing same is greater than the value of the timber.

(*b*) Sheeting is tongued and grooved when driven in water-bearing material to keep water out or freely-flowing sand, mud, etc. It is tongued and grooved for coffer-dams, caissons, etc., to make water-tight compartments.

68. Under what conditions as to nearness of excavation, depth, character of soil, etc., would you consider it necessary to underpin buildings on the line of the subway?

Generally speaking, buildings whose foundation walls are above grade of tunnel and within 10 ft. of excavation require underpinning if the soil adjacent to excavation is of yielding or mobile character and cannot safely be supported by sheeting.

69. When water is being pumped from the soil in the excavation, how would you determine whether it is endangering surrounding buildings?

Examine the water discharged by the pumps, noting whether it is clear or contains material underlying the building foundations adjacent to the excavation. If the water is continually charged with this material, the foundations may be endangered.

70. Give essential features of the process of underpinning a large building and every precaution to be taken.

The essential features are:

1. The preparation of a firm foundation bed at or below subgrade of excavation, to which the load carried by the piers or columns is transmitted.

2. The erection of footing courses and columns on these foundation beds, as in the case of permanent structures.

3. The setting of beams or cantilevers on these supports and wedging them under structure to be supported to prevent settlement.

The precautions to be observed are:

1. In excavating for foundations, etc., shafts and trenches should be dug as small as possible and far enough from building foundation not to endanger it.

2. The operation of wedging should be done with great care, so as to prevent undue strains.

71. Suppose a sewer crosses the work and has to be replaced by three smaller ones to make room for the work; is it sufficient to simply make them of a total equivalent section, or what else must be considered? State fully.

No.

The *discharging capacity* of the three small sewers must be equal to that of the sewer to be replaced. Since the wetted perimeter and consequently the friction of the three sewers is greater than that of the larger sewer, the velocity and therefore the discharge will be diminished. To obtain the same discharge, three sewers must be selected whose combined area is large enough to compensate for the loss due to increased friction.

72. Describe alteration in line of a large brick sewer and method of caring for the flow meanwhile.

The sewer is built along the new alignment, and when ready to join on to the old work a bulkhead of brick or cement bags is built at the points where the change of alignment begins and ends, the arch between the points having been removed. A temporary flume (or flumes) of sufficient size to carry the maximum flow, with the ends built into the bulkheads, is suspended or supported in the line of the old sewer, and far enough above the invert to permit the construction of the new invert at the points of connection. The old invert is now removed and the new work built and the connections made, when the bulkhead and flume are removed and the flow turned into the new sewer.

73. Describe briefly the operation of supporting and moving a large water main so as not to interfere with its use.

Block up the pipe on skids, long enough to permit lateral motion and having solid bearing. The skids are lubricated so as to facilitate the motion of the blocks on them. The lead joints being somewhat flexible and the spigots being set in far enough, slight motion is possible without causing leakage. Jacks are placed at the side of the pipe bearing against the trench walls or other solid support. Each length of pipe is now moved laterally a small amount, and the operation repeated until the required change is effected.

74. How is condensation prevented on station walls and roofs?

Condensation is prevented by providing a 1-in. air space between the station walls and roof and the concrete side walls, this air space extending from the ceiling to within a foot of the platform and communicating by vents with the outer air. The air space between the ceiling and roof jack arches prevents condensation on roof.

75. Describe how the standard railway track is best maintained in line and grade.

The rails are securely spiked to the ties set $1\frac{1}{2}$-ft. centers, the latter being provided with tie plates.

Tie rods between rails at intervals of 10 to 15 ft. are used to maintain gauge. Good trap rock ballast is placed on the concrete floor and thoroughly wedged under and between the ties and around the ends to maintain the grade and line.

76. If a brick sewer is to be replaced by a number of cast-iron pipes so as to pass under the subway, how would you calculate the number and size of these iron pipes?

First ascertain the discharge of the brick sewer. Then decide tentatively on the number of iron pipes to be used.

Each pipe is to carry its proportion of the flow.

The length of each pipe is fixed by the width of the tunnel.

Then by the ordinary formulas for the flow of water in pipes the diameters are obtained. If these diameters are not convenient a different number of pipes is assumed and diameters recalculated, and so on until the proper number and size are obtained.

77. Describe damp-proofing and its methods of application.

"Damp-proofing" consists of a continuous sheet of asphalt and felt embedded within the concrete of the top, sides and bottom of the tunnel, completely enveloping it.

On the prepared surface of the concrete floor, side or roof of the tunnel a layer of hot asphalt is spread; on this a layer of felt is immediately rolled out while the asphalt is hot and made to stick over the entire surface; the joints in the felt should be broken. Care must be taken that the ends of the rolls of the bottom layer are carried up on inside of the layers on the sides and those of roof on outside with about a 3-ft. lap. On this layer of felt successive layers of asphalt and felt are laid in the same manner, two to six layers being used, according to nature of the ground. One or more courses of brick dipped in hot asphalt may be used in place of the above.

78. Outline specification for back-filling subway near adjacent sewer.

Filling should consist of sand, gravel or good clean earth free from stones over 8 in. in diameter and not containing more than one portion of stone to three of earth. It should be deposited in layers no more than 9 in. thick, watered and packed by rammers weighing not less than 30 lb., and in such manner that no unbalanced pressure can be thrown upon subway or sewer. Filling must be carefully packed and rammed about sewer, using special tools. No filling should be made with frozen earth. Sheeting should be carefully withdrawn as fast as filling progresses or may be left in place.

79. What do the specifications call for in regards to the storing of cement?

Cements should be stored in a tight building protected from the weather. The packages should be placed on a floor or platform raised several inches above ground. When stored out of doors canvas should be placed around them. Ample storage room should be provided so that lots can be separated for identification.

80. How would you store materials as to public safety and convenience?

Materials must not be piled within 4 ft. of any fire hydrant or fire alarm box. The Fire Department must be given access at all times and in all places to all buildings for extinguishing fires.

All material should be watered if stored temporarily in street, if so ordered. Paving stones, flagging, etc., if to be reused, shall be moved at once to another block or neatly piled along route, so as not to obstruct use of walks and street by pedestrians and vehicles.

81. How would you arrange the reports of your inspectors or other subordinates so as to obtain correctly the actual cost of any portion of the work?

Classify the work under proper headings.

Tabulate under each heading the forces employed and the material used.

Apply the prevailing rate of wages and the market price of material to compute the cost of each class of work.

To the cost thus computed add an allowance of about 15% for superintendence and also an allowance for interest and depreciation of plant to arrive at the total cost.

The unit cost of any class of work can then be found by dividing the total cost of that class by the number of units completed.

82. How would you inspect a job of riveting?

With a special hammer weighing about a pound, blows are struck sharply on each side of the head of the rivet.

Loose rivets will be indicated by jar or rattle.

Also examine edges of rivet head, observing that there are no marks of caulking tool. See that the heads are concentric, fit closely all around and are free from cracks, and that no impress on the metal around the head has been made in driving the rivet.

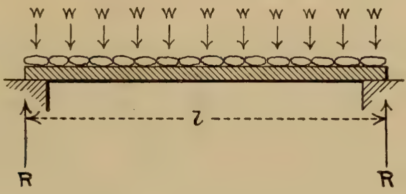
The rivet heads should be full size.

83. In inspecting (*a*) a piece of finished riveted work, what defects would you look for in the riveting, (*b*) in a heavy casting as a base of a column?

(*a*) See Question No. 82.

(*b*) In inspecting castings look for honeycomb. Blow holes or sand holes when filled with sand or loam are detected by a dullness in sound, upon tapping. Examine also for shrinkage cracks, large ridges at partings and flaws on edges. Warped castings or those that are incorrect in dimensions should be rejected.

84. Make a sketch of a beam uniformly loaded. Show reaction at each support in terms of $w\ l$, etc., and moment at center.



w = weight per unit, l = length of span, R = reaction at support.

$$R = \frac{w\,l}{2}$$

$$\text{Moment at center} = R \times \frac{l}{2} - \frac{w\,l}{2} \times \frac{l}{4} = \frac{w\,l}{2} \times \frac{l}{2} - \frac{w\,l^2}{8} = \frac{w\,l^2}{8}$$

85. Describe the method of transmission of electrical power by a third rail, stating briefly its advantages and disadvantages.

The third rail is divided into sections one-half mile or so in length, and receives its power from feeders passing through ducts along tunnel wall and under station platforms. These feeders or cables, proceeding from the power house or substations, are tapped at various intervals, supplying direct current at about 550-600-volt pressure to the third rail. Insulating blocks electrically separate the third rail from the track or subway floor, which acts as the return circuit. The advantages are cheapness, simplicity of construction, economy of space.

Disadvantages are danger in case of accident; its exposure and easy accessibility, endangering life.

86. Write a report on a job of pile driving for the abutments of a bridge and for getting in the footings of the same.

The report should include: (*a*) the character of the foundation, number and spacing of piles, their original lengths and diameters, the kind of timber, etc., depth to which they are driven, description of apparatus, weight and fall of ram, penetration of last blows, etc.

(*b*) The grade and amount of cut off, the net lengths remaining in, and the total lineal feet of piles to be paid for should be given. The number of piles delivered, used and rejected, the reasons for rejection, the number broken and pulled up should be tabulated.

(*c*) The formulas used and tests for the bearing power of piles.

(*d*) For getting in the footing courses the report should give depth and extent of excavation, depth of footing course and offsets, the proportion, character of ingredients, methods of mixing and laying the concrete, forms and amount of timber used.

(*e*) Force and material accounts.

87. Make a report and write specifications for materials and building of a 20-ft. semi-circular arch, assuming it to be 2 ft. thick.

They should include a detailed description of the site, of the character of the foundation for the side walls, giving results of borings and test pits, if any. It should also contain calculations and method of design of arch, giving loadings assumed, etc. Also estimate of quantities, of cost, time, and comparisons between costs of different materials. Specifications should cover the following items: Excavation, rock and earth; cement, sand and broken stone, if any; mortar, how mixed; masonry, the various classes in structure; method of laying, centering, timbering, etc.; character of spandril filling; method of striking of centers, etc.

88. At *Times* station why is there 1 ft. between platform and entrance to cars?

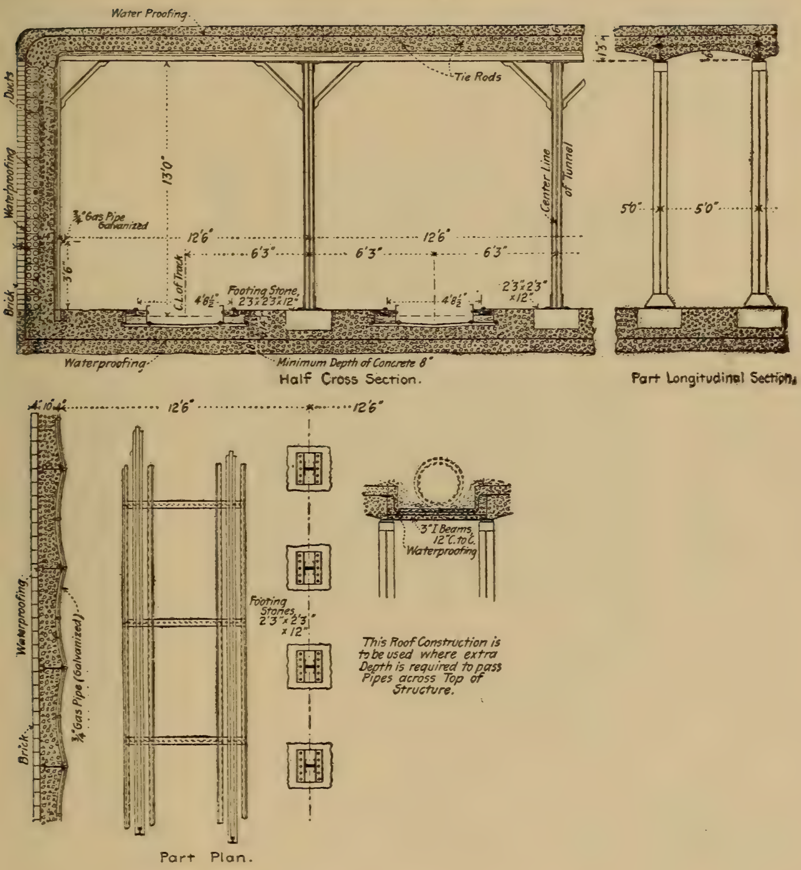
The edges of station platforms at Times Square are on curves parallel to the tracks. To permit cars of train to pass around same, the side of the car being parallel to a chord of the curve, a clearance of 1 ft. between platform and car entrances is required.

89. How would you figure the spacing for the iron bents of the subway when on a curve?

On the center line of the tunnel the iron bents should be spaced the same as on the tangents—5 ft. apart.

The inner and outer bents are on radial lines to the curve, so that the inner spacing will be less than and the outer spacing more than 5 ft., the distance being computed from the respective radii.

90. Show by sketch a typical vertical cross-section of a four (4) track tunnel where it is necessary to keep close to the surface, including important dimensions and indication of materials used.



Cross-Section of New York Subway.

(From Stauffer's "Modern Tunnel Practice," by permission.)

Typical Form for Monthly Estimate.—90 Per Cent. Payment

THE CITY OF NEW YORK. Estimate No......................

To... ....Dr.

For work measured and estimated in constructing................................, under a contract dated.................................from ....1. , to..................................1, .

Total Quantities Estimated to Date Including Present Estimates.	Total Quantities Previously Estimated.	Approximate Quantities Meaured and Estimated for above Month.			Description of Work Done.	Unit Prices.	Monthly Amounts. Dollars.	Monthly Amounts. Cts.	Total Amounts. Dollars.	Total Amounts. Cts.
2 000	1 000	1 000	*a*	cubic yards	Removal of soil taken from spoil banks, including all work incidental thereto.	0.30	300	00	600	00
2 000	1 000	1 000	*aa*	square yards	Sodding, including all work incidental thereto.	0.20	200	00	400	00
2 000	1 000	1 000	*b*	cubic yards	Earth excavation, including the disposal of it, and all work incidental thereto.	0.30	300	00	600	00
2 000	1 000	1 000	*c*	cubic yards	Rock excavation, including the disposal of it, and all work incidental thereto.	2.00	2 000	00	4 000	00
2 000	1 000	1 000	*e*	M. ft. B. M.	Permanent timber work, placed and fastened, including all work incidental thereto.	55.00	55	00	110	00
2 000	1 000	1 000	*f*	barrels	Portland Cement, in barrels of 400 pounds, ordered by the Engineer, and placed in the work, including all work incidental thereto.	2.50	2 500	00	5 000	00
2 000	1 000	1 000	*g*	cubic yards	Concrete masonry in place, formed of five parts of broken stone, or gravel, or a mixture of both, to one part of cement, and made with American Cement Mortar mixed in the proportion of one part of cement to two parts of sand, including all work incidental thereto.	4.00	4 000	00	8 000	00
2 000	1 000	1 000	*h*	cubic yards	Brick masonry, not included in item (*h h*), laid in American Cement Mortar mixed in the proportion of one part of cement to two parts of sand, including all plastering and pointing, all scaffolding, centers, forms, etc., and removing the same, and all work incidental thereto.	9.00	9 000	00	18 000	00
2 000	1 000	1,000	*i*	cubic yards	Rubble stone masonry, laid in American Cement Mortar mixed in the proportion of one part cement to two parts of sand, including all work incidental thereto.	3.00	3 000	00	6 000	00

	Monthly Dollars	Cts.	Total Dollars	Cts.
Total amount estimated			$42 700	00
Total amount previously estimated			21 355	00
Total amount of present estimate........................			$21 355	00
Total amount of work measured and estimated between the above dates........................	$21 355	00		
Deduct 10 per cent........................	2 135	50		
Balance due for work measured and estimated during the month........................	$19 219	50		

I hereby certify that this is a just estimate of the approximate amount of work measured and estimated between the...........and....... days of..............................190.. both inclusive.

Chief Engineer,

MANUAL OF EXAMINATIONS

FOR

ENGINEERING POSITIONS

IN THE

SERVICE OF THE CITY OF NEW YORK

QUESTIONS AND ANSWERS
IN 3 VOLUMES

VOL. I. AXEMAN, CHAINMAN AND RODMAN, LEVELER, TRANSITMAN AND COMPUTER
VOL. II. ASSISTANT ENGINEER
VOL. III. DRAFTSMAN, AND INSPECTOR

VOL. II. PART II.

ASSISTANT ENGINEER
GENERAL, AQUEDUCT, DOCKS, SEWERS & HIGHWAYS

INDEX

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THE ENGINEERING NEWS PUBLISHING COMPANY
1906

PREFACE.

In the "Previous Examination Papers," which have been included in this book, the questions may not, in all cases, be identical in wording with those actually given at the examinations, as copies of the original papers are not readily procurable, but they do embody the substance of questions asked.

The papers marked "Miscellaneous Questions" are compiled from many sources, having their origin at examinations held previous to the dates given, and are inserted to enhance the value of the book.

In the section devoted to "Typical Questions and Answers," great care has been taken to make the answers conform with the best modern practice. Reasonable variance of opinion may exist as to what is the best answer, owing to differences in interpretation of the questions and in education and experience, but it is sufficient to say that the answers are based on such recognized authorities as Trautwine's "Civil Engineer's Pocket Book," Baker's "Masonry Construction," Byrne's "Highway Construction and Inspector's Pocket Book," Merriman's "Hydraulics," Fanning's "Water Supply," and Patton's "Civil Engineering."

In order to perpetuate the value of the book, blank leaves have been inserted after the "Previous Examination Papers," allowing for the convenient addition of new sets, and the "Typical Questions and Answers" have been interleaved to provide space for notes, sketches and additions.

PREVIOUS EXAMINATION PAPERS.

ASSISTANT ENGINEER—GENERAL.

Salary, $1 200 to $3 000 per annum.

Miscellaneous Questions, Covering a Number of Assistant Engineers' Examinations.

October, 1891.

1. Show graphically the resultant of three or more forces acting in the same plane.

2. $V = \sqrt{2\,g\,h}$. What is the value of g? Give application.

3. What is a vernier?

4. What is your method of calculating earthwork?

5. What instruments are necessary in laying out a curve, and describe their uses?

6. What are the physical differences between American Portland and Rosendale cements? How are they manufactured?

7. How do you test cement?

8. Find the horse-power of a stream, discharge 100 cu. ft. per sec., fall 10 ft.

9. What practical method do you know of for measuring the discharge of running water in open channels?

10. Give formula for above, or state where it can be found.

11. In a rectangular dam where is the center of pressure?

12. Where should the line of pressure on an arch fall?

13. What is the law of liquids at rest?

14. How high can you pump water with a suction pump, at sea level?

15. At 7 000 ft. above sea level?

16. What do you mean by the grade line of a pipe, and its hydraulic grade line?

17. What relation should exist between them?

18. What is the wet perimeter of an egg-shaped sewer 3 ft. x 2 ft. running full?

19. What is the number of bricks in a running ft. of 8-in. work?

20. When would you prefer pipe and when brick sewers?

21. What is the horse-power necessary to lift 2 240 lb. 100 ft. per sec.?

22. What is the safe load for earth foundations?

23. What is the best method of preserving piles in sea-water?

24. Same in ground?

25. What is the weight of a cast-iron wedge 1 ft. x 2 in. x 3 in. high?

ASSISTANT ENGINEER—GENERAL.

MISCELLANEOUS QUESTIONS—BROOKLYN, Dec., 1894.

1. What is meant by the acceleration of gravity, and what is it in figures?

2. Through what distance does an ordinary body fall in the first second and third seconds; and what is its velocity at the end of each second, in feet?

3. Do these distances hold good at all points on the earth's surface? If not, where are they the least or most?

4. What is the fundamental law or equation upon which the flow of water in pipes, conduits, streams, etc., is based, and what modifications in it are necessary when it is applied to particular cases (if answered by equations explain the symbols)?

5. Given two reservoirs 500 ft. and 2 000 ft. sq., and filled with water 20 ft. deep, the banks being 25 ft. high, how much heavier or thicker should the wall or bank be in the one case than in the other, and why?

6. If, in running a line in an open level country, you find it passes through a house near to the bank of the stream which the line would cross, how would you pass the obstacle, triangulate through it and across the stream, get the distance and continue the line if you had no note books or tables but only your surveying instruments?

7. How would you proceed if your line ran east and the stream northwest and southeast and you had to do all your triangulation on the north side of your line?

8. What is the ordinary velocity of sound per sec., and does the velocity vary with the temperature or not? If so, how?

9. What is the boiling point of water at sea level, and how does it change as you rise above the sea? What change for 5 000 ft. rise?

10. What is the average rainfall in the vicinity of New York City and how much of it may usually be expected to flow down the streams? Answer in inches of rainfall. If not familiar with this locality, answer concerning the locality in which you have been through most of 1894.

11. Describe method of ascertaining the horse-power of a running stream, and give an illustration and example, including a

sketch of a weir in a stream. How much of the theoretical horse-power can be obtained in practice, and delivered to a line shaft in a mill?

12. Show by means of diagrams the sines, cosines, tangents, co-tangents, versed sines and co-versed sines of one angle of about 40° and one of about 150°.

13. Describe method of making and laying concrete, stating what tests of cement should be made, how to select or secure good sand and stone, size of latter, the proportion of each with Rosendale or Portland cement, and the manipulation of materials so as to secure good results. What is meant by "voids" in engineering practice?

14. Suppose a double-track standard gauge railway, which now runs through a street, is to be lowered 25 ft. and made to run through a tunnel under the street, the surface of which then will be given up to ordinary street traffic. The entrance to the tunnel will be faced with stone and have wing walls at an angle with the track, the arch being rather flat. Sketch roughly the elevation of a suitable entrance, making it to a scale of ⅛ in. to 1 ft. and designate the different kinds of masonry, names of different parts and kind of material which should be used.

15. The above tunnel after passing the entrance will have side walls with vertical face and a brick arch. Sketch this section, and describe the parts from foundations to street surface: making sketch on scale ¼ in. to the foot (sketch need only show as much of the construction as can be put in a space 6 in. wide. It can be broken off on one side of center line).

16. What is meant by the terms "separate system" and "combined system" in sewers?

17. What is a catch basin, and what is its use? Sketch one and describe construction.

18. What is a manhole, and what is its use? Sketch one and describe construction.

19. What is a flush tank, and describe its uses?

20. Sketch an oval sewer, *i. e.*, egg-shaped, and give radii of all arcs in terms of greatest horizonal width.

21. What is the reason for the use of an oval sewer?

22. What is meant by hydraulic mean radius?

23. What is the proper maximum velocity of flow through sewers?

24. What is the minimum slope allowable for 6-in., 9-in., 12-in. and 24-in. sewers and the least allowable in any sewer?

25. For what rainfall per hour, reaching the sewers, should a sewer be designed for an area of 20 acres; also for 500 acres?

26. Having a rainfall of 2 in. per hour in a well-paved compactly built city, what size circular sewer having a fall of 2 ft. in 100 would be necessary to carry off the water from an area of 20 acres, assuming that all the rainfall reaches the sewer? Show calculation or describe it, if you would use tables such as you would expect to have in your office, state just what the tables are, where they would be found, and how you would use them.

27. Would the sewer run full or only partly full?

28. If left with you to decide, would you make this sewer a pipe sewer or an oval brick sewer?

29. Describe order of work in a street where you wish to lay a pipe sewer and be sure that each pipe is on exact grade.

30. What are the different kinds of road or street surfaces in use in American cities, and in what order of merit would you arrange them? Begin with common dirt road.

31. What are "curb" stones and "bridging" in street work? Of what material should they be, and of what dimensions? To what extent should they be dressed?

32. Describe the steps of construction of a first-class pavement and street to take the place of a common dirt road.

33. Sketch the finished work. Suppose roadway to be 40 ft. wide and two sidewalks each 10 ft. wide. Note various measurements.

34. How is the best granite block pavement constructed, and what would such work as you describe cost per square yard?

35. How is the best asphalt pavement constructed?

36. Where are the principal asphalt deposits found? What is the difference between "land asphalt" and "lake asphalt" from Trinidad, chemically?

37. Is an asphalt pavement injured by water standing upon it and, if so, how does it deteriorate?

38. To what tests would you subject a brick to determine whether or not it was suitable for use in street pavements?

39. Describe the construction of a first-class brick pavement, giving sketch and dimensions of brick and of the different parts of the pavement from curb to curb.

40. What are the advantages and disadvantages of different kinds of pavements?

41. What are current prices of pavements in the vicinity of New York?

42. What is a maximum safe load, in pounds per square foot, to place upon good dry sand or good earth in constructing foundations?

43. Sketch a timber crib suitable for a bridge pier and describe it.

44. Sketch a pneumatic caisson for bridge pier.

45. Sketch a coffer-dam for bridge pier.

46. Sketch a Howe truss, and name different members.

47. Explain the terms "positive" and "negative" in electricity and state what is meant when a water main is said to be "negative" to a rail in a track above it.

48. To prevent or reduce electrolysis of water pipes should the pipes be positive or negative to the rail and why?

49. What is meant by the term "duty" as applied to pumping engines?

50. If a metal has a breaking strength of 1 000 000 lb. per sq. in. in tension, how thick should a 12-in. pipe (inside diameter) be, to safely conduct water from a reservoir which has a water surface 200 ft. above the point of delivery? Show the calculation.

ASSISTANT ENGINEER--GENERAL.

Miscellaneous Questions—New York, 1896.

1. What is your experience in civil engineering?

2. Have you ever pursued a course of study in any institution or with any civil engineer, which fits you for the position of assistant engineer?

3. Have you ever had any responsible charge of any public work? State particulars.

4. Solve the following according to the algebraic signs and show work.

5. The population of a certain town, in 1880, was 7 095; it having increased 25% in 10 years, what was it in 1870? Show your work.

6. How many feet board measure in the flooring of a room 20 ft. by 30 ft. and $2\frac{1}{2}$ in. thick?

7. Find the value of x and y in the following equations:

$$2x + 3y = 33,$$
$$4x - y = 17.$$

8. Find the value of x in equation: $x^2 - x - 40 = 170$.

9. Find the value of x in equation: $x^2 + x + 40 = 100$.

10. Explain the meaning of the expression $(a + x)^{\frac{3}{2}}$:

11. What is a logarithm?

12. What is the base of the common system?

13. In making what calculations are logarithms useful?

14. How do you find the logarithm of a number in the table of logarithms?

15. What are similar triangles?

16. How are similar triangles proportioned to each other?

17. The sides of a polygon being prolonged, what is the sum of all the exterior angles equal to?

18. How do you pass the circumference of a circle through three given points not in the same straight line?

19. How do you describe a square in a circle?

20. Make a sketch of the form of cast-iron beam best adapted to resist a transverse strain.

21. How do you describe a regular hexagon in a circle?

22. What proportion do circumferences and areas of circles bear to their radii?

23. How do you find the area of a regular polygon?

24. How do you find the area of an irregular polygon?

25. How do you find the area of a circle?

26. How do you find the solid contents of a cylinder?

27. How do you find the solid contents of a wedge?

28. How do you find the solid contents of a pyramid?

29. Find the contents of the wedge, base 20 ft. x 30 ft., height 10 ft., edge 15 ft.

30. State the prismoidal formula; would you use it in calculating earthwork?

31. Calculate the following sections, cutting being denoted by plus, filling by minus; both being written over the distance from the center, slopes 1 to 1.

32. How many and what parts of a plane triangle must be given to find the rest?

33. Define the terms sine, cosine, tangent and co-tangent.

34. What are natural sines, cosines, etc.?

35. What is a table of logarithmic sines, cosines, etc.?

36. Two sides and two angles of a plane triangle being given, how do you find the other parts?

37. When two sides of a plane triangle and the included angle are given, how do you find the other parts?

38. In the right-angle triangle, express algebraically the value of the sine, cosine, tangent and co-tangent.

39. What is the law of gravitation?

40. Do you understand that there is any difference in the meaning of the terms of gravitation and gravity?

41. What is the law of falling bodies?

42. Express algebraically this law, calling v velocity of falling body; a acceleration of gravity; and h height.

43. What is the center of gravity of a body?

44. How is it found?

45. Where is the center of gravity of a homogeneous body whose sides are all rectangles?

46. What is the specific gravity of a body?

47. What is the standards for solids and liquids?

48. What for gases?

49. What laws govern the pressure of liquids at rest?

50. How do you find the number of gallons of water to the cubic foot?

51. What is the weight of a gallon of water?

52. What is the pressure per square inch on the side of a vessel at the depth of 10 ft. below the surface of the water?

53. What will be the theoretical volume of discharge per second from a reservoir through a pipe 1 ft. in diameter, discharging at a depth of 100 ft. below the surface of the water?

54. How many gallons of water will be discharged through a pipe 1 ft. in diameter, 328 ft. long, head 13½ ft. coefficient of flow pipe 1 ft. in diameter, 328 ft. long, head 13½ ft. coefficient of flow = .007?

55. State how many men are needed to make up a full party for a survey of a preliminary line or location of a public work, such as a railroad or aqueduct.

56. State also their several duties.

57. For what purpose is the magnetic needle used in surveying land?

58. What is a traverse table and what is it used for?

59. How do you set out a circular curved line upon the ground?

60. If an obstacle occurs to alignment, state how you would overcome it upon straight lines; also upon curves.

61. The radius of a curve being given and angle of intersection of two tangents, how do you find the length of the tangent from their intersection to the beginning of the curve?

62. Describe the engineer's transit, and name its adjustments.

63. Describe the Y level and name its adjustments.

64. How many kinds of leveling rods do you know of?

65. State how they are graduated, and how they can be read to thousandths of a foot.

66. Show a form of field book for transit notes used when "running curves," and place thereon notes of a 5°-curve for 1 000 ft., with two intermediate set ups.

67. Show a form of level-book, and place thereon sufficient figures to show your method.

68. What are cross-sections?

69. How do you set slope stakes for excavation and embankment?

70. What is a grade line?

71. What proportion of the breaking weight of a beam would you consider a safe load?

72. With the load uniformly distributed, what fractional part of the whole weight may be considered, in all calculations, as being carried at the center?

73. Suppose a beam supported at both ends, and take w = weight 1 = length of beam, b = breadth, d = depth, S = breaking weight, express algebraically the value of S in terms of the other quantities.

74. Sectional area being 36 sq. in., which would be the stronger section, 6 x 6 or 4 x 9?

75. Make a design for a pair of rafters, connected by a tie beam, for a roof 30 ft. span, showing the dimensions of the several parts and the manner of connecting them. State in detail your method of obtaining several dimensions.

76. How do you apply the principle of the parallelogram of forces in determining the strain on the various members of a structure; illustrate graphically.

77. What should be the thickness at the top and base of a retaining wall 15 ft. high, built to retain ordinary earth? Show your method of obtaining the required dimensions; also a sketch of the wall, showing how it should be founded.

78. A reservoir is to be built—depth of water 10 ft. If the walls are built of masonry, find the thickness of the same, and state how they should be built. Show your work.

79. What is an arch, of how many forms, and of what may it be constructed?

80. Can you state how you would find the thickness of an arch of stone, span and rise being given?

81. Define the intrados and extrados of an arch.

82. Where should the line of resistance to pressure be found in an arch in order to retain its stability?

83. How can you find the thickness of the abutments, the rise and span of the arch being given?

84. In the semi-circular arch, where is the horizontal thrust greatest and where least?

85. Name the common kinds of stone used in building.

86. Define the terms "quarry-faced," "rough-pointed," "fine-axed," "bush-hammered," as applied to the dressing of stone.

87. Describe "rubble" masonry, "ashlar" masonry, and "broken ashlar" masonry.

88. What are "headers" and stretchers?"

89. What should be the proportion of "headers" to "stretchers"?

90. How would you prepare the foundation of a heavy wall, and how deep should it be excavated?

91. How are walls founded on soft or yielding materials?

92. Describe a good quality of bricks, and state how you would know a good brick from a poor one.

93. In how many ways is brick work "bonded" to make good work in heavy walls?

94. What is hydraulic cement, and how many kinds do you know of?

95. Which do you consider the better cement, Rosendale or Portland, and why?

96. What is mortar composed of, and how mixed?

97. What kind of sand should be used, and how do you test its quality?

98. What is the meaning of the term "setting" as applied to cement?

99. How would you test cement?

100. What is concrete; of what composed, and in what proportion should its ingredients be mixed?

101. Name the common kinds of wood used in building.

102. What kind of timber resists decay longest underground?

103. How may timber be preserved from decay?

104. What do you understand by limit of elasticity as applied to a beam under strain or pressure; what is meant by the neutral axis of a beam?

105. What is the tensile strength of a good quality of wrought iron per square inch?

106. For what parts of a structure may cast and wrought iron be used in reference to tension and compression?

ASSISTANT ENGINEER—GENERAL.

New York, Feb. 23, 1897.

1. State the duties of an Assistant Engineer.

2. Write specifications for broken stone, sand and cement in first-class concrete, and give details of mixing and laying.

3. Write specifications for brick to be used in a large sewer, and give method for laying same.

4. Give sketch of a retaining wall 20 ft. high, to retain earth, and give dimensions.

5. If above wall is in massive blocks, write specifications for wall and exact way in which stone must be manipulated for best results.

6. Suppose the earth behind the wall is liable to be very wet at times, may any method be employed to reduce the danger to the wall?

7. A segmental arch has a rise of 5 ft. and a span of 40 ft., state approximately how much the horizontal thrust would be increased by an additional center load of 40 000 lb.

8. Define the line of thrust, and in designing an arch where should it fall?

9. How would you design the base of abutment of an arch?

10. Suppose abutment to be built on compressible ground, give sketch of foundation you would use, with dimensions, and give reasons for each step.

11. What is the safe load for a well-driven pile?

12. Give safe loads for clay, sand, gravel and loam.

13. Give weight of cast iron, wrought iron, water, moist sand, concrete, brickwork with close joints, and limestone masonry.

14. Write specifications for piles and method of driving.

15. Write specifications for 12-in. pipe sewer, in reference to quality, testing and delivery of pipe.

16. Write specifications for laying pipe sewer, including refilling in trenches.

17. Describe points to be observed in digging a trench where blasting is likely to occur, trench being near a water main.

18. Describe in detail the method of laying a 36-in. water main.

19. Write monthly estimate for regulating, grading and paving a street with stone blocks.

20. Give estimates for materials for a 4 ft. brick sewer 1 000 ft. long.

21. An important sewer is to run along a line, part through rock, part through unknown material and balance to outlet over salt marsh. Being directed to make an examination of the line, write your report stating everything done and give recommendations.

ASSISTANT ENGINEER—GENERAL.

New York, August 20th, 1897.

1. Draw diagram showing radius and length of a curve and tangent, and also tangent to both sides.

2. Sides of a triangle are 120, 60 and 70, find the area.

3. Give relation between sine, cosine and tangent.

4. How would you give grades for a sewer?

5. What are the conditions of the stability of a retaining wall?

6. Show graphically how to adjust an error of closure.

7. What precautions should be taken in building a retaining wall?

8. How would you lay out a simple curve?

9. To what points would you pay special attention to in laying a water pipe?

10. How would you determine what size of culvert to use?

11. How would you guard against a washout?

12. How would you make a survey to determine capacity of a reservoir?

13. How would you compute above capacity?

14. There is a load on the roof of 12 lb. per sq. ft., horizontal wind pressure 30 lbs. per sq. ft., rafters 3 ft. apart; find stresses in all members.

15. What is the center of pressure and find it on a rectangular gate immersed in water.

(Board of Public Improvements, Dept. Highways, Etc.)

1. State in detail what experience you have had in topographical work, drainage and highway construction, which would especially fit you for this class of work; giving place and kind of work.

2. (*a*) What use is made of the magnetic meridian in surveys? (*b*) State the sources of error in making a survey by the magnetic needle. (*c*) Are surveys usually made with magnetic needle?

3. (*a*) Name the different kinds of pavements in use in cities. (*b*) Give a brief description of each. (*c*) State the conditions under which each can be used.

4. (*a*) What is rubble masonry? (*b*) Ashlar masonry? (*c*) In what engineering structures is each used and when are brick masonry and concrete used?

5. Give the angle of intersection and P. C. of a street or railway curve, show how you would run out the curve.

6. Where a street or railway in embankment crosses a stagnant pond the bottom of which is soft material state what method you would pursue in making an earth-fill across the same to obtain a permanent embankment.

7. (*a*) Where a street crosses a valley by embankment sustained by a retaining wall of masonry, show how you would obtain the dimensions of the wall. (*b*) Explain the theory of pressure of earth against a retaining wall.

8. What is the least grade desirable in a street gutter and how would you arrange the grade in a street where the existing grade between two intersecting streets is too flat for proper drainage?

Promotion to Assistant Engineer, Borough of Richmond,

August 25th, 1902.

1. Describe the different kind of street pavements and show dimensions and construction.

2. What is the minimum allowable gutter grade for granite block pavement?

3. What is the minimum allowable grade for 6 in., 8 in. and 12 in. sewer pipe?

4. What is the maximum allowable grade for asphalt pavement?

5. What is the method for calculating areas from traverses?

6. Calculate the area of an egg-shaped sewer equal to 10 ft. circular and show construction in soft wet gravel.

7. What is the greatest allowable error in precise leveling for 4 miles?

8. What is a fair closure of 20 angles in a traverse?

9. Show design for retaining wall with earth slope of 45° from top—also show design for abutment of arch bridge at tide water.

10. Show method of calculating sizes of outfall of lateral sewers.

ASSISTANT ENGINEER—GENERAL.

Technical.

New York, October 9, 1899.

1. (*a*) What do you understand by the "angle of repose" of earth? (*b*) At what point above the base of a retaining wall will the centre of pressure from earth behind it be located, when the earth is level with the wall?

2. (*a*) Within what limits of the base of a retaining wall or the abutments of an arched bridge, must the line of thrust fall to insure stability? (*b*) What proportions of headers to stretchers should be used in an abutment wall?

3. About what pressure per square foot can safely be placed on the following materials in founding structures upon them where liable to be continually wet; (*a*) stiff clay; (*b*) loam; (*c*) gravel? (*d*) In taking loamy earth from a "borrow pit" what difference in cubical contents will there be between the "borrow pit" and the complete "fill."

4. What is the difference between "refraction" and "reflection" as applied to light, and how does the former affect the line of sight taken through a level?

5. Suppose you had in leveling to take 1 600 feet sights; how can you do it with reasonable accuracy and eliminate the effects of "curvature" and "refraction"?

6. What are the several qualities of cast and wrought iron and wrought steel which make them useful for various classes of engineering construction? Describe briefly the work for which each is well adapted and in general the methods by which you would test them.

7. Outline briefly the essential points to be covered in specifications for timber piles and pile-driving.

8. Describe the various ways of shaping and using sheet piling to keep water from work in progress.

9. What is hydraulic cement, and what are its properties and uses as regards engineering construction? Outline briefly the methods by which you would test the relative merits of two or more samples.

10. Show a form for monthly estimate to a general contractor, including at least six items of material or labor on some kind of city engineering construction; assume quantities and set unit val-

ues agreeing approximately with present market values; carry out the arithmetic, show percentage returned and previous payments.

REPORT.

Write a report covering at least two pages on the location and design of some public work with which you are acquainted, giving the reasons why the design was adopted in the form given. Also give the progress of the work up to some given time, containing such items as a progress report to your chief ought to contain.

MATHEMATICS.

Give all the Work on the Ruled Sheet.

1. If 12 men can shovel 90 yd. of earth in an hour and a half, how many men will be required to shovel 2 550 yd in a working day of 10 hr.?

2. A culvert must take drainage from 1 000 acres. How many cubic feet per second must be carried by the culvert?

Use formula $Q = c\,y\,\sqrt[4]{s\,a^3}$, where Q equals cubic feet per second reaching culvert; c equals proportion of rainfall reaching culvert; y equals rainfall per hour; s equals average slope of water shed in feet (per 1 000 ft. of horizontal distance) and a equals acres of water-shed. (Give values to c, y and s according to your judgment; exact quantities are not required.)

3. A grade of 1/270 is how much per 100? How much per mile?

4. A building is 50 ft. wide and the pitch of a peaked roof is 30°. What is the length of the rafter. With rafters spread 10 ft. apart what is the strain in the rafter from a uniform load of 30 lb. per square foot of horizontal area?

5. Extract the square root of 47 065.06.

EXPERIENCE.

1. Have you taken a regular course of instruction as an engineer in any college or technical school? If so, at what one? What was the length of the course, and what degree or diploma did you receive, if any?

2. If you have not taken such a course, state what your education as an engineer has been.

3. Have you followed any mechanical pursuit, and if so, what, and how long.

4. State what experience you have had in the practice of engineering, particularly in City work.

5. If there are any other points you consider important in your experience that would help you as engineer, state them.

ASSISTANT ENGINEER—GENERAL.

AUGUST 12TH, 1904.

1. In foundation work, if you meet with quicksand, what would you do?

2. A retaining wall, vertical back will have a road filled in rear. Given, grade of road, width, etc., with two cross-sections, side slopes $1\frac{1}{2}$ to 1, compute fill for 100 ft. of the length.

3. Write a report not less than 500 words on the Riverside Drive Extension, describing the construction of a trunk sewer and transverse sewers connecting with same to drain private dwellings along the Drive.

4. Give sketches showing three types of sidewalks and state different characteristics.

5. How many cubic yards of broken stone, sand, Portland cement will it take to make 100 yards of concrete,

3-in. broken stone having 50% voids,
2-in. broken stone having 40% voids.

The 2-in. stone will fill the voids of the 3-in. stone; the sand will fill the voids of the 2-in stone; the cement will fill the voids of the sand; 10 bbl. cement will make one cu. yd. What is the percentage of the mixture?

6. Draw outline of arch, of reinforced concrete, 100-ft. span, ornamental design, and give principle for calculating same.

7. Describe the design and construction of a retaining wall.

8. How would you collect data for passing a large trunk sewer or roadway through an embankment and under the roadbed of a steam railway? Show by sketch.

9. Give the adjustments of the transit in their order, and duties of transitman when accurate work is required.

10. Give the adjustments of the level and duties of a leveler for accurate work.

11. Explain in detail a complete topographical stadia survey, its advantages and limitations.

12. Show a monthly estimate of contractor of, piles furnished in place, yellow pine lumber, brickwork, concrete above water and steel beams, prices consistent with foundation work, estimate to be assumed about middle of work.

13. Bulk in place being assumed at 100, what would be the percentage in embankment for loam, dry; loam, wet; loam, rolled; soft clay; stiff clay; sand; gravel?

14. Describe the construction of macadam roads; give their principal features and outline specifications for 100 ft. of same.

15. Describe the construction of Telford roads; state their characteristics, and write specifications for 100 ft. of same.

16. What are wooden piles used for? How is their bearing power determined?

17. Sketch sewer manhole and show connection with main sewer.

18. What do you consider a suitable maximum and minimum grade for roads? For streets?

19. A road having an 8% grade is intersected by a road having a 6% grade at right angles. Show sketches of intersection, giving all dimensions.

20. A circular sewer has inside diameter of 9 ft. Sketch sewer of another type, vertical height 4 ft., to be just as efficient.

21. Describe the method of laying asphalt pavement over old block pavement. What precautions would you take?

22. How would you drain an extensive park site?

ASSISTANT ENGINEER—AQUEDUCT COMMISSION.

Miscellaneous Questions.

1. Describe the duties of an Assistant Engineer in the Department.

2. Given a water shed, having an area of 10 sq. miles with 5% water surface. Calculate the storage necessary for daily supply of five million gallons and the dimensions of a spillway to provide for a flood of 80 cu. ft. per second per sq. mile.

3. Given an overflow masonry dam 8 ft. wide on top with vertical back, front batter 6 in. per ft., height 25 ft., weight of masonry 140 lb. per cu. ft., flood 2 ft. over, show whether or not the dam will be stable.

4. How would you measure the discharge of a small stream (*a*) on which a tight dam is situated; (*b*) without a dam.

5. Describe in detail how you would make a topographical survey and map of a water-shed, 15 miles long, 2 to 6 miles wide, for 5 ft. contours, giving organization of field and office forces, instruments and supplies.

6. Calculate the opening necessary in a road culvert having a fall of 3 in. in 30 ft., to carry the flood flow of a brook draining 1.25 sq. miles of farm country, with a general slope of 5 ft. in a thousand.

7. How would you clean the aqueduct?

8. How would you gauge the daily flow of the aqueduct?

9. What is the value of the co-efficient (n) in Kutter's formula, for the new aqueduct?

10. Give the formula for flow of water and explain terms.

11. Give the fundamental formula for amount of discharge and explain.

12. An earth dam is to be 40 ft. high. Give the best cross-section and state in detail how you would construct such a dam.

13. When springs and fissures are encountered in a masonry dam site, how would you proceed?

14. When a spring of very high head is encountered on a masonry dam site, how would you proceed?

15. What is "puddle"? What are the best proportions of material to form it?

16. How would you prevent water following a pipe line through a dam?

17. Give size, shape, etc., of stone and best method of building a masonry dam.

18. Suppose the upper surface of a dam to be vertical. (*a*) State at what depth the center of pressure of water will be located. (*b*) State what the pressure per foot of length of the dam would be, taking the depth as in (*a*).

19. (*a*) In what part of a stream is the velocity greatest? (*b*) On what functions does the velocity of a stream depend? (*c*) Describe principal ways in which average velocity of stream is obtained.

20. The velocity in a sewer running full equals the velocity when half full. Explain the reason for this.

21. State all the points to be observed in building a perfect weir.

22. What is the effect of imperfect contraction or of small depth of water over a weir. How is velocity of approach allowed for?

23. Where does the contraction of the fluid vein have to be considered in designing a pipe line?

24. State all the losses of head in a pipe line, and how they are diminished.

25. Give diagram of pipe line with undulating grade and show what is meant by hydraulic gradient. What provision should be made to insure successful work? Note: the latter part of this question refers to the case when the grade of the pipe is above the hydraulic gradient.

26. Write a report on a site for an important dam. Also on a reservoir wall, an earth embankment and a puddle core wall.

ASSISTANT ENGINEER.

Department of Water Supply and Aqueduct Commission.

1899.

1. What training and experience have you had in the design, construction and maintenance of water works?

2. (*a*) What is the maximum, minimum, and average annual rainfall in the Croton Valley?
(*b*) What proportion of this can be assumed as available for storage?

3. In building a masonry dam, state all precautions to be observed to prevent leakage and secure first-class work.

4. (*a*) In building a dam, what would you do where small springs were encountered?
(*b*) What, where large springs or considerable water?

5. State, in detail, method of constructing an earthen dam.

6. Give the different methods of measuring the velocity of flow in a stream.
(*b*) Where is the maximum velocity in cross-section of stream?

7. Given a reservoir dam, show lines of pressure and make calculation for stability. (Approximate result only.)

8. Given a stream; volume 120 cu. ft. per sec., fall 12 ft., efficiency of wheel 80%, find foot-pounds of work of stream and horse-power of wheel.

ASSISTANT ENGINEER—AQUEDUCT COMISSION.

PROMOTION EXAMINATION—1903—SALARY $1800.

1. (*a*) What is your age? (*b*) At what technical school did you graduate? When did you graduate? (*c*) If not a graduate, under what engineer have you studied, and how long have you studied? (*d*) State fully your full experience in charge of work, with dates. Note. Omissions or discrepancies in dates count against the applicant.

2. State fully the duties of the position to which you desire promotion.

3. Describe the operation of cleaning the aqueduct.

4. State how the daily flow in the aqueduct is gauged.

5. In the application of Kutter's formula in computing the flow, state what the value of the coefficient (n) is found to be.

6. In computing the flow in an open channel by the ordinary formula, what quantities are required?

7. Suppose a dam is to be founded on rock, and on uncovering the rock it is found to be seamy, with water coming up at points, what would you do?

8. Suppose there is a spring with considerable head, what can be done?

9 and 10. Draw a section of an earthen dam to cross a valley, the depth to rock below the surface to the ground being 25 ft. at the deepest point, and the water surface to be 30 ft. above the ground at the same point. Give every detail to produce safe work and give reasons.

11. What can be done to prevent water from flowing along a pipe which passes through a reservoir wall?

12. In laying up a masonry dam, what measures as to shape of stone, cutting same, bounding same, and laying same, will tend to make the tightest work?

13. (*a*) Describe the material which makes the best puddle. (*b*) Suppose you have to prepare puddles from materials on a work, how would you do it?

14 and 15. Write a report on your examination of a valley for the best location of a dam. Describe fully the examination made, the result of your examinations, and the reason for the location you have made.

ASSISTANT ENGINEER—AQUEDUCT COMISSION.

SALARY $1800. JUNE 21, 1904.

1. Does the quality of cement (particularly of Portland cement) for hydraulic work, depend in any way upon its storage?

(*a*) If so, state clearly how it is affected by storage.

(*b*) State what may be the after effect upon a structure of lack of care in this respect.

(*c*) Describe the proper storage of cement.

2. (*a*) Upon what does the imperviousness of concrete to the passage of water depend? (*b*) Describe clearly and fully the method you would take to determine the best proportions of the several ingredients in order to make water-tight concrete.

3. State what you know about the *mechanical* anaylsis of sand, gravel, etc.

4. When an earth bank for a reservoir, or canal, is to be placed on earth, does the surface need any preparation, and if so, what and why?

5. (*a*) Suppose a masonry dam is to be founded on rock, and after excavating to it, the rock is found to be seamy with water flowing from the seams. How should the rock be treated? (*b*) If the springs are very strong flowing, what must be done? (*c*) In such a dam, what would determine the depth to which examinations by drill or otherwise, should be carried?

6. Make a sketch showing how the foot of a slope wall on the inside of an earthen reservoir bank should be supported and give your reasons for the construction shown?

7. Write a suitable clause for the specifications for the stone work in a large masonry dam, describing the character of the stone as to shape and dimensions and the bond to be observed? State your reasons? (Stone setting is asked in next question.)

8. Describe minutely everything to be done in setting a large rubble block in the heart of such a dam from the time the stone is lifted until the setting is complete? (*b*) What objections, if any, are there to the use of grout in such a case? State fully and clearly.

9. (*a*) Describe clearly the usual method of tunneling in sound rock where timbering is not required? (*b*) How may the progress and cost of a tunnel be affected by carelessness of the Contractor in blasting and otherwise?

10. Sketch a form of centre with approximate dimensions to be used in treacherous rock in a tunnel like that of the Aqueduct?

11. (*a*) In building a large sewer, or a piece of the Aqueduct where quicksand is encountered, how do you proceed to get sound work? (*b*) Under what conditions does quicksand of itself make a safe foundation?

1. Find the area of an ellipse, whose diameters are respectively 10 ft. and 6 ft.

2. Find the solid contents of the frustum of a cone, whose radii are respectively 7 in. and 11 in., and whose height is 17 in.

3. In a rectangular borrow-pit 50 ft. by 40 ft., the following are the cuts at 10 ft. intervals, both ways. Compute the cut (omitting side slopes) by the shortest method of averages.

7.	5.6	6.1	6.7	7.3	8.
6.6	5.3	6.	6.5	7.	7.5
6.3	5.2	6.	6.2	6.9	7.2
6.5	5.1	5.9	6.	6.5	7.
6.	5.	5.6	5.9	6.3	6.6

4. The average section of a stream for a distance of 100 ft. is as follows; the fall of the stream is in the same distance 0.12 ft.:

25 ft. Left.	Depth	=	0	ft.
15 " "	"	=	6	"
5 " "	"	=	8.5	"
Center	"	=	10.	"
5 " Right	"	=	8.5	"
15 " "	"	=	6.0	"
25 " "	"	=	0.0	"

Take (c) = 88 in the formula $V = c\sqrt{R\ S}$ and determine the value of V.

1. What is your age?

2. Have you graduated from a technical school or college? (*a*) If so, give name and location of same. (*b*) State the date of entrance and of graduation?

3. Have you studied under an Engineer in addition to a technical course? (*a*) If so, give his name and residence. (*b*) State what your studies were under him. (*c*) State how long you were a student under him. (*d*) Give the date when you began with him and when you finished. (*e*) State what work in the field you did while studying under an Engineer.

4. In addition to your experience while a student, state every other item of practical experience you have had. (*a*) In each case state location and kind of work. (*b*) State in every case what you had to do with it personally—that is, your position and specific duties. (*c*) State when you began the work in every case, and when your connection with it ceased.

5. State any other facts or experience which tend to make your services of value as an Assistant Engineer.

6. Give the names and addresses of at least two persons to whom application can be made for verification of the answers to the foregoing questions.

BOARD OF WATER SUPPLY.

ASSISTANT ENGINEER—GENERAL—TECHNICAL.

SALARY $1 350 PER ANNUM.

OCTOBER 12, 1905.

Note: Elaborate discussions are not required. Clear, concise answers covering the essential points will receive highest rating.

1. State (without describing in detail) the several adjustments, in their proper order of (*a*) the surveyor's transit; (*b*) level.

2. Explain briefly the method of stadia survey and show a form for notes, filling in such as are taken in the field and leaving blank those which are worked out in the office.

3. Explain how a drainage area is determined.

4. (*a*) How is the total rainfall for any area determined? (*b*) How the available rainfall? (*c*) State the full information for both necessary for purposes of securing water supply.

5. Describe briefly the several methods of measuring the flow of water in streams.

6. Name the watersheds available for supply of New York City and state briefly the advantages and disadvantages of each.

7. (*a*) Give the Chezy formula and explain its terms. (*b*) In what does Kutter's formula modify it?

8. State the causes of failure of retaining walls and the precautions necessary to prevent failure.

9. State briefly the important points regarding mixing (by machine) and placing heavy concrete masonry.

10. Describe briefly the several methods of sinking wooden piles and the conditions under which each would be used.

11. Discuss briefly the methods of handling quicksand in constructive work.

12. Draw a section of an earth dam, the depth of rock below earth surface being 20 ft.; the water surface to be 25 ft. above the ground. Show every detail to produce safe work.

13. Explain briefly the method of tunneling through rock.

14. Same through soft mud below water.

15. State the prismoidal formula and show by sketches its use in calculating the contents of an earth embankment.

Mathematics.

Give all the figuring on the ruled sheets.

1. Extract the square root of 2030.4063036 to four places of decimals.

2. Reduce 35.2 in. per second to feet per minute and miles per hour.

3. Find the area of a triangle the sides of which are 50, 60 and 70 ft. respectively.

4. How many cubic feet of water per second will be discharged by a canal 125 ft. wide at top, 75 ft. wide at bottom, 10 ft. deep and 2 640 ft. long with a fall of 40 ft. (Take c equals 88.)

5. What is the weight of a cast-iron pipe 12 ft. long, 4 ft. inside diameter, 1 in. thick, allowing $2\frac{1}{2}\%$ for increase of metal in hub and spigot?

Report.

Assume reasonable facts and write a suitable report of not less than two nor more than three pages on any one of the following subjects:

(*a*) The general avalability of the Watershed as a source of supply for New York City.

(*b*) The Hudson River as a possible source of supply.

(*c*) A proposed filtration system.

(*d*) A proposed storage reservoir adjacent to New York.

(*e*) The comparative merits of a steel re-enforced concrete conduit and a brick conduit.

(*f*) Possible methods of reducing water consumption in New York.

ASSISTANT ENGINEER—INTERMEDIATE GRADE.

SALARY $1 650.

OCTOBER 17, 1905.

1. Describe the making of an accurate triangulation survey.

2. State the principle (*a*) of the pressure of water; (*b*) of the siphon.

3. Discuss the use of steel to re-enforce concrete.

4. Explain the method of designing a steel water tower 100 ft. high, 40 ft. in diameter.

5. Outline specifications for brick mortar and work of construction of a large brick conduit.

6. Show by sketches and describe the method of carrying a large conduit over a marsh.

7. Describe clearly the method of accurately determining the character of foundation for an important dam.

8. Explain in detail the most accurate way of gauging the velocity of a stream.

9. Explain the method of designing a masonry arch viaduct to carry an aqueduct.

10. State what you know regarding evaporation from water surface, from snow and ice and from earth.

11. State what you know regarding sedimentation in reservoirs and its prevention.

12. State the important points to be considered in the construction of an open canal for carrying water supply.

13. Describe the theoretical design of a heavy masonry dam.

14. State the important details of construction of (*a*) a heavy masonry dam; (*b*) such features as are peculiar to concrete.

15. Show a proper form for an intermediate monthly estimate to a contractor of following items, with reasonable cost prices: (*a*) Clearing and grubbing; (*b*) Earth excavation (with convenient waste); (*c*) Rock excavation (in considerable quantity); (*d*) Sheet piling, left in place; (*e*) Concrete; 1, 3, 5 (in mass); (*f*) Random, coursed rubble monumental masonry.

ASSISTANT ENGINEER—HIGHEST GRADE.

SALARY $2 000.

OCTOBER 17th, 1905.

16. Describe how the flow of water in circulating pipes is affected by friction, stating the various cases and assigning values for each and quoting your authority.

17. Explain how to ascertain the time required to empty a reservoir.

18. State all the important points which should be considered in the choice of a reservoir site for gravity water supply.

19. Design an "aqueduct" section conduit of concrete re-enforced with steel.

20. Describe fully a system of water filtration suitable for a large city.

21. A stone arch bridge must take the drainage of 5 000 acres. How many cubic feet per second must be carried? (Use formula Q equals $c\ y\ \sqrt[4]{S\ O^3}$, in which c equals 50, y equals 1.5 and s equals 12.

22. Assume bridge semi-circular for 50 ft. roadway; design opening and show by sketches approximate construction.

23. State briefly the successive steps necessary to secure information regarding the availability of a watershed for purposes of water supply.

24. Explain the theory of rain and that of the amount of rainfall as affected by winds and mountain ranges.

25. Discuss the important points to be considered in the construction of a large distributing reservoir as is proposed near Yonkers.

DEPARTMENT OF DOCKS AND FERRIES—PROMOTION TO ASSISTANT ENGINEER.

August 18th, 1896.

1. Describe in full, detail of operation of making a hydrographic survey for a pier on the North River, together with the location of property lines.

2. Give specimen page of a note book containing such a survey.

3. Describe methods pursued in obtaining a knowledge of the earth strata, etc., at the site of the pier.

4. Give careful pencil sketch, with dimensions of the standard form of wall used by the Department where the mud is very deep.

5. What type of wall is used in hard bottom and what type where rock is near the surface?

6. State as fully as possible the reasons for the adoption of this method of construction.

7. What is the angle of repose as applied to earth and what relation does it bear to the angle of maximum pressure?

8. In case of retaining wall, at what angle will the earth sustain rupture, in case of the movement of the wall?

9. In what ways do retaining walls fail?

10. Without increasing the dimensions of a retaining wall what precautions in filling behind it, will increase its safety?

11. A derrick has a mast 40 ft. high, a beam 35 ft. long, and a topping lift 25 ft. long. There is a weight of 10 tons supported at the end of the beam. What is the horizontal pressure at the top of the mast?

12. In the testing of elastic material, such as iron, what is the meaning of the term "elastic limit" and about what proportion does the stress at that point bear to the ultimate strength?

13. What are the respective weights of a cubic foot of fresh and salt water?

14. What is the standard weight of the atmosphere?

15. In using drift bolts for fastening timber what precautions are necessary to obtain the greatest possible holding power in the timber?

16. Describe the building of a standard concrete block in detail.

17. Describe the setting and lining up of one of these blocks.

EXAMINATION FOR PROMOTION TO ASSISTANT ENGINEER.

Department of Docks and Ferries.

December 1st, 1899.

1. State your age and training and experience you have had in any form in connection with the design, construction or maintenance of wharves, docks, bulkheads or any other works of a similar nature.

2. What pressure per square foot of foundation would you consider it safe to allow on a gravel bottom or one of coarse sand, when it can be protected from wash or other disturbance?

3. (*a*) On what elements does the bearing power of a pile depend?
(*b*) How would you decide upon the safe load to be applied to any given pile which you have seen driven?

4. When the foundation of a bulkhead is on rock, is any preparation of the rock ever necessary; and if so, what, and for what reasons?

5. Suppose a pile near the outer end of a pier to have an average diameter of 15 in., and the depth of water to be 35 ft. What would be the total pressure against its surface resulting from a tidal current with an average velocity of 4 miles per hour?

6. (*a*) Give careful sketches (plan, etc.), on a large enough scale to show clearly every part (fastenings included) of the outer 80 ft. of a pier 60 ft. in width, with dimensions of parts.

7. Give careful sketches of one panel of an iron and slate roof and supports for such roof, dimensions of parts not required, but constants for loading, strength of iron, channels, angles and riveting to be given.

Second Paper.

1. When a bulkhead must be built on material which is compressible and unstable to a considerable depth, show how substantial work may be done and explain principles governing the design of such work.

2. State all requirements of a strictly first-class pile for important work.

3. (*a*) State the difficulties encountered in using fresh concrete under water, and all the ways you know of for doing such work in a reasonably satisfactory manner, when it must be done.

(*b*) State what tests a cement should stand which is to be used in the manufacture of bulkhead blocks.

4. (*a*) State what ingredients in cement are detrimental?

(*b*) To get the very best hold in timber when round bolts are used, how must the work of boring be done and what precaution must be taken?

5. Describe the best method of setting concrete blocks for a bulkhead under water, including location as to line and level and every element of good work.

6. Describe in full detail the method of sounding an area under water in a tideway so as to get accurate depths and locations.

7. To what plane of reference should surroundings in a harbor be referred, and for what reasons?

ASSISTANT ENGINEER—DEPARTMENT OF DOCKS.

1. What experience have you had in the design, construction and maintenance of docks and bulkheads?

2. Sketch section of standard bulkhead where good bottom is found at moderate depth.

3. How should cement be tested for use under water?

4. Sketch section of standard bulkhead where poor bottom is found at considerable depth.

5. How would you determine safe bearing power of piles?

6. State all the methods you know of for sounding under water.

7. Give all details of making large concrete blocks used in bulkheads.

ASSISTANT ENGINEER—SEWER DEPARTMENT

April 24th, 1899.

1. What methematical knowledge should an assistant engineer in the sewer department possess? Give your reasons.

2. What are all of the duties that an assistant engineer may be called upon to perform?

3. Describe what experience you have had in this work that entitles you to promotion.

4. Explain in detail all the refinements that should be observed by the leveler and rodman in running an accurate line of levels.

5. What method should a transitman and flagman observe in running a long transit line accurately?

6. (*a*) How frequently should receiving basins be placed on a street? What rule governs this?

(*b*) How frequently should manholes be placed on a street? Give your reasons.

7. Should a sewer built to carry off the rainfall from a thousand acres be ten times as large as one built to carry off the rainfall from 100 acres? Give your reasons.

8. How would you measure the quantity of water flowing in a sewer?

9. Calculate the diameter of a sewer to carry off one inch of rain per hour from 100 acres, the grade being 1 in. in 100 feet.

Assume formula as follows:

$$D = \sqrt[5]{Q^2\ L \div 1.5\ H}.$$

Q = Cu. ft. per sec. of water discharged.
L = Length of sewer in feet.
H = Fall per feet.
D = Diameter in feet.

10. State what you understand by "separate" and "combined" systems of sewers, and which you consider the better in any case.

11. Describe and sketch the best bond for use in brick sewers and state why.

12. Describe the proper method of joining a brick sewer to main sewer as regards to shape, grade, and everything that may appertain thereto, with reasons.

13. Sketch a complete cross-section of a large brick sewer (giving dimensions) to be built across a very soft piece of ground, showing whole construction, including foundation.

14. How would you determine the safe weight to put upon a given pile you may have seen driven?

12. (*a*) What is the largest size of vitrified pipe in use?

(*b*) Give in detail the best manner for laying pipe so as to give the freest flow in a sewer of small descent.

16. Write a report, as an assistant engineer, to your superior on the most important work you have been connected with; giving a description of the work, what has been accomplished; the reason why certain plans were followed, and everything else that you think would be of account in such a report.

ASSISTANT ENGINEER—SEWER DEPARTMENT.

New York City, November 29, 1899.

1. What training and experience have you had in the design, construction and maintenance of sewers?

2. Sketch standard manhole for 36-in. brick sewer with 12-in. pipe branch; show elevation of section across sewer and plan at about flow line.

3. (*a*) For what rate of rainfall should sewers in New York City be designed?

(*b*) What proportion of this is assumed as reaching the sewer? Is it a constant, and show, if you can, how this is introduced in the formulas for diameter of sewers.

4. When would you use the egg-shaped section for sewers?

5. When is the velocity greatest in a sewer, when it is running full or half full or how is it?

6. (*a*) What is meant by hydraulic mean radius?

(*b*) Does resistance to flow depend on this, and how?

7. What is the least allowable velocity of flow in sewers, and why?

8. What is the best bond for brick sewers?

MANUAL OF EXAMINATIONS

FOR

ENGINEERING POSITIONS

IN THE

SERVICE OF THE CITY OF NEW YORK

ASSISTANT ENGINEER
GENERAL, AQUEDUCT, DOCKS, SEWERS & HIGHWAYS

TYPICAL QUESTIONS AND ANSWERS

TYPICAL QUESTIONS AND ANSWERS.

Assistant Engineer—General.

1. What are the duties of an assistant engineer?

He is usually required to take responsible charge of one or more parties or sections of work. He must direct such work, look after all details, handle his men to advantage and protect the interests of the City. He may be placed in charge of surveys for topographical, hydraulic, drainage, street opening and other purposes, or on construction of bridges, sewers, water works, docks, highways, &c. He is often required to prepare plans, specifications and estimates or examine and report on the condition and quality of work in progress.

The assistant engineer is expected to be familiar with the work of the computer, draftsman, surveyor and estimator, and to possess executive ability, initiative capacity, tact and judgment.

2. What is meant by the acceleration of gravity?

The acceleration of gravity is the increase in the velocity of a freely falling body. A body starting from a state of rest, acquires a velocity of 32.16 ft. at the end of the first second, 64.32 at the end of the 2nd second, &c. The acceleration (g) is thus 32.16 ft. per sec.

3. Through what distance does an ordinary body fall in the 1st, 2nd and 3rd seconds; what is its velocity at the end of each second, in feet?

Distance passed through in first second				$= S_1 = 16.08$ ft.
"	"	"	2 seconds	$= S_2 = 4 \times 16.08.$
"	"	"	3 "	$= S_3 = 9 \times 16.08.$
"	"	"	n "	$= S_n = n^2 \times \frac{1}{2} g.$

Therefore

Distance passed through in 2nd second $= S_2 - S_1 = 3 \times 16.08 = 48.24'$.

Distance passed through in 3rd second $= S_3 - S_2 = 5 \times 16.08 = 80.40$.

Distance passed through in nth second $= S_n - S_{n-1} = [n^2 - (n-1)^2] \times 16.08$.

The velocity at the end of the nth second $= n \times 32.16$.

4. Do these distances hold good at all points on the earth's surface? If not, where are they least and where most?

The value of the acceleration of gravity, and therefore the quantities depending upon it *are not* the same in all parts of the earth. It is least at the equator and greatest at the poles. It is modified by the form and rotation of the earth.

The earth being an ellipsoid and not a sphere, the surface at the equator is farther from the center than it is at the poles, and the velocity of rotation at the equator is therefore also greater; the result being that g at the equator is less than at the poles, the difference being about 0.16 ft. per sec.

5. What is the specific gravity of a body?

The specific gravity is the weight of the body as compared with the weight of an equal volume of pure water, at 4° C. It is equal to its weight in air divided by the loss of weight when immersed in water.

6. What is the standard for solid and liquids?

The standard is pure water at 62° F. 32° F. and 39.1° F. are sometimes used as standard temperatures.

7. What for gases?

The standard for gases is air at atmospheric pressure (15 lb. per sq. in), and at 32° F.

8. What is the standard weight of the atmosphere?

The standard weight is 0. 080728 lb. per cu. ft.

9. What are the respective weights of a cubic foot of fresh and salt water?

Fresh water weighs about 62½ lb. per cu. ft.
Salt water weighs about 64 lb. per cu. ft.

10. Give the weights of cast iron, wrought iron, water, moist sand, concrete, brickwork (close joints), and limestone masonry.

Weight of	cast iron	= 450	lbs.	per	cu.	ft.
"	" wrought iron	= 480	"	"	"	
"	" moist sand	= 100	"	"	"	
"	" brickwork	= 100	"	"	"	
"	" limestone masonry	= 150	"	"	"	
"	" rubble	= 150	"	"	"	
"	" concrete	= 130	"	"	"	
"	" cement natural	= 60	"	"	"	
"	" cement Portland	= 80	"	"	"	
"	" mortar	= 100	"	"	"	

11. What is the center of gravity of a body?

The center of gravity is that point through which passes the resultant of all the forces of gravitation acting on the elementary particles of the body so that if suspended at this point all the parts will be in equilibrium.

12. How is it found?

In regular homogeneous bodies it coincides with the center of figure.

The position in irregular bodies may be found by experiment or by dividing the body into simple figures in which the position of the center of gravity is known and then computing by moments the position of the center of gravity of the entire body.

13. Where is the center of gravity of a homogeneous body whose sides are all rectangles?

At the center of figure.

14. What is the ordinary velocity of sound per second, and does it vary with the temperature or not? If so, how?

The ordinary velocity is 1 090 ft. per second in air at 32° F. It *varies* with the temperature, increasing about a foot for each degree increase in temperature, being about 1 060 ft. per sec. for 0° F., and 1 160 ft. per sec. for 100° F.

15. What is the boiling point of water at sea level, and how does it change as you rise above sea level? What change for 5 000 ft. rise?

At sea level water boils at 212° F. The boiling point decreases about 1° for each 520 feet rise, being about 202° at 5 000 ft.

16. State (without describing in detail) the several adjustments in their proper order of (*a*) the surveyor's transit; (*b*) level.

(*a*) The adjustments of the transit are:

1. Adjustment for parallax—to bring the image in the plane of the cross hairs.

2. Adjustment of the plate levels—to make them perpendicular to the vertical axis, so that the plate will be horizontal when bubbles are in the center.

3. Adjustment of the cross hairs—to make the line of sight perpendicular to the horizontal axis, so that it will generate a plane as telescope is revolved in altitude.

4. Adjustment of the horizontal axis—to make it perpendicular to the vertical axis, so that the line of sight will generate a *vertical* plane as telescope is revolved in altitude.

5. If telescope is provided with a bubble tube the axis of the tube must be made parallel to the line of sight, if the instrument is to be used for leveling.

(*b*) The adjustments of the level are:

1. Adjustment for parallax.

2. Adjustment of cross hairs—to make the line of sight coincide with the axis of the telescope.

3. Adjustment of the long bubble—to make the axis of the tube parallel to and in the same plane with the line of collimation.

4. Adjustment of the Ys or standards—to make the axis of the pivot rings perpendicular to the vertical axis, so that the bubble will remain in center in all positions of the telescope.

17. Describe the making of an accurate triangulation survey.

A reconnaissance is first made of the area to be surveyed, with a view to the best possible location of base lines and triangulation stations.

Base lines as long as possible near each end of the area are selected, monumented, and chained, using all possible refinements so that the error does not exceed 1 in 100 000.

The stations at the ends of one of the base lines are then occupied by the transit instrument, and angles read to all visible triangulation stations which have previously been selected or established.

The instrument should be the best obtainable, the adjustments as perfect as possible and all precautions taken to eliminate error. The angles should be read by repetition and series and the work held to a possible error of one second per angle or less. The closing angle to complete the horizon should be taken at each station occupied.

Each triangulation station is then occupied in turn, angles being taken to all others visible, until every possible station, including those at the ends of the second base line, have been occupied.

The angles are then examined, errors distributed and the co-ordinates of each station computed, starting with the co-ordinates of either base and checking on the length and bearing of the other.

18. Describe in detail how you would make a topographical survey and map of a watershed 15 miles long, 2 to 6 miles wide, for 5 ft. contours, giving organization of field and office forces, instruments and supplies.

The first consideration is the amount of time given to complete the survey. Taking one year as the basis, the work would be divided into three divisions, each about five miles long, headquarters being centrally established for each division.

The organization of the forces would be as follows:

Chief Engineer in Charge of Work.	Division A. 3 Field Parties and office staff...	1 Assistant or Division Engineer in charge. 3 Transitmen or Assistant Engineers in charge field parties. 3 Levelers assigned to field parties. 10 Axemen and Rodmen. 3 Draftsmen and Computers. 2 to 4 Laborers—(Drivers or Caretakers). 3 to 5 Computers and Draftsmen in office.
	Division B. 3 Field Parties and office staff.	Same as Division A.
	Division C. 3 Field Parties and office staff..	Same as Division A.

The equipment of each division would be 3 transits (stadia) and necessary bobs, sighting apparatus 3 levels and necessary leveling rods, 3 plane tables and necessary stadia rods.

A liberal supply of tapes, axes and usual surveyor's sundries.

Two horses, a stage and a buggy, necessary attachments, office furniture, draughting materials, etc.

The first step in the survey is to establish a primary traverse system (which should be tied to some established lines) around the reservoir site, monumenting all principal points balancing, and plotting the work. The error in the primary traverse work should not exceed 1 in 50 000. The main traverse can then be divided into squares having sides of about ½ mile in length, all stations being referenced, co-ordinates computed and plotted.

During the progress of the traversing, lines of bench levels starting at a known point should be run accurately around the watershed following the main traverse lines, the elevations of all stations being determined.

Plane table sheets covering about $\frac{1}{2} \times 1$ mile of area and mounted on rollers should in the meantime be prepared by the draftsman, the scale being 1 in. = 100 ft.

The established traverses should be plotted on the sheets and the field parties given a list of all references, co-ordinates, benches, etc., that they may have occasion to use.

Sheets are assigned to the several parties, who fill in all topographical details, recording elevation of all hollows, ridges, water surfaces, changes of slope and grades of roads and other points controlling the positions of contours. The location of all points may be obtained with the stadia and vertical angle and the contours interpolated, or where the ground is not too steep the contour may be directly "followed" with the level and rod and correctly drawn on the sheets. All buildings, fences, property lines, roads, streams, ponds, culverts and all other details must be obtained.

Additional stations and benches are established by the several parties as required.

As each sheet is finished it should be turned over to the draftsman and inked while the details are fresh in the mind, and other sheets assigned to the field party until the entire area has been mapped. As adjacent sheets are completed they are carefully compared so that any error in the work can be detected.

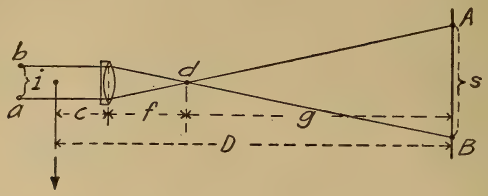
19. Explain briefly the method of stadia survey and show a form for notes, filling in such as are taken in the field and leaving blank those which are worked out in the office.

The transit should be supplied with a compass and a vertical arc. The rods should be of the self-reading pattern, easily read from the instrument. Make all the adjustments and note the index error of the vertical arc. Measure the focal distance (f) of the objective and the distance (c) from the reticule to the objective, giving the stadia constant ($f + c$).

Stake out a line about 800 ft. + ($f + c$) setting stakes at $100 + f + c$ from point of beginning and at every 100 ft. point thereafter.

Set up transit at the zero of the line and take readings on stadia rod held at each stake. The hairs should be adjusted so that 1 ft. on rod will equal 100 ft. ($+ f + c$) from instrument, or

the ratio per hundred feet may be obtained from the observed readings.



$$s : g :: i : f$$

$$g = \frac{f\,s}{i} = k\,s \qquad D = k\,s + (f + c).$$

Run a traverse around area to be surveyed, obtaining lengths of the sides with the stadia, and their azimuths; also establish bench marks around the traverse, obtaining elevations of all stations.

The azimuth of the starting courses may be obtained by an observation on Polaris or by traversing from known lines. To get the azimuth of the succeeding course, set vernier on azimuth of back course, sight on back station with the telescope normal, plunge telescope and turn on forward station. The reading on the limb will be the new azimuth. The back sights and fore sights should be taken and averaged for the lengths of the courses and the lengths reduced to the horizontal.

After the traverse has been closed, set up on each transit station, take shots on all prominent points, such as tops of ridges and bottom of hollows, fences, buildings, roads, streams, culverts, noting the azimuths, distances to each and vertical angles when the latter exceed about 5°. All other details should be located and amplified by sketches when necessary.

Auxiliary stations should be established when required, as judgment dictates.

When a station is once occupied care should be taken that all necessary data are obtained from it.

Whenever the transit or level is set up at a new point a check reading should first be taken on an established point to check the orientation and the H. I.

By means of a stadia chart or table the observed distances are reduced to the horizontal. The notes should be plotted as soon as possible while still fresh in the mind. (For inclined sites, distance $= k\ s\ \cos.^2\ a + (c + f)\ \cos.\ a$ and diff. elev. $= \frac{1}{2}\ k\ s\ \sin.\ 2a + (c + f)\ \sin\ a$.

The contours may be interpolated between the plotted points or they may be directly "followed" and changes in direction located.

FORM OF NOTES.

Date.....		Party							Remarks and Sketches.
Sta	Azim.	DISTANCE.			V. A.	Hor. Dist.	Diff. in Elev.	Elev.	
		F. S.	B. S.	Av.					
*F	*F	*F	*F	†O	*F	†O	†O	†O	

* Columns marked F are filled out in field.
† " " O " " " " office.

20. What methods are usually employed in calculating earth-work? Describe them.

There are two methods in common use:

1. The average end area method.
2. The prismoidal formula.

In the first case volume included between two successive stations

$$= \frac{A + A_1}{2} \times l$$

A = area section at one end.
A_1 = area section at other end.
l = distance between ends.

By prismoidal formula:

$$\text{Vol.} = (A + A_1 + 4Am) \times \frac{l}{6}.$$ Am = Area of section midway between A and A_1.

The sum of all the partial volumes will give the total volume.

The areas of the cross-section at any station may be obtained—

1. By means of the planimeter.
2. By direct computation, from the cuts and fills.
3. By plotting on cross-section paper and counting squares.
4. By cutting sections out of cardboard and weighing same, the unit weight being known.

21. What are the several qualities of cast and wrought iron which make them useful for various classes of engineering construction? Describe briefly the work for which each is well adapted and in general the methods by which you would test them.

Cast iron is durable, possesses great strength in compression, and can be readily cast in any desirable shape, making it a convenient material to use for water pipes, columns, column footings, bed plates for machinery, etc.

It, however, is brittle and should not be used where subject to heavy vibration, impact or tensile stresses.

In inspecting castings, look for honeycomb. Blow holes or sand holes when filled with sand or loam are detected by a dullness in sound on tapping. Examine also for shrinkage cracks, large ridges at partings and flaws on edges; warped castings and those of incorrect dimensions should be rejected.

For testing the strength, bars 14 or 26 in. long, 3 in. wide and 1 in. thick are prepared and the breaking load transversely and in tension obtained, the resulting deflection and elongation being also noted.

Two principal varieties of cast iron are made: White, which is hard, brittle and difficult to work; gray, which is soft, tough and malleable when cold.

They differ in the amount of carbon in chemical combination.

Wrought iron is adapted to structures which are subject to alternating compressive and tensile stresses, but in which the unit stresses are not excessive, such as rivets, beams, girders, truss members, columns, etc. The metal is durable, malleable, elastic and readily worked.

In inspecting wrought iron look for "cold short" (containing phosphorus), indicated by bright crystalline fracture and discolored spots; also for red short (containing sulphur, arsenic, etc.), indicated by cracks on edges of bars.

Tough iron has a fine, fibrous and close texture.

Wrought iron is tested by bending prepared bars hot and cold. No fracture should result.

The tensile strength is determined from test pieces usually about 18 in. long by 1 in. wide, and the original thickness.

22. Name the common kinds of wood used in building and state the purpose for which each is used.

Ash—Used for interior and cabinet work.
Cedar—Used for posts, ties and fences.
Cypress—Used for interior work.
Elm—Used for ties and bridge timber.

Hemlock—Used for rough lumber for construction.
Locust—Used for fence posts and ties.
Maple—Used for interior work.
Oak—Used for ties, posts and where strength is required.
Palmetto—Used for under water construction.
Pine, red, yellow, white—Used for all construction purposes.
Spruce—Used for piles and construction purposes.
Walnut—Used for interior work.

NOTE: For complete table of properties of woods see Byrne's "Inspector's Pocketbook," p. 56.

23. How may timber be preserved from decay?

There are several methods in use for the preservation of timber:

1. Burnettizing or impregnation of the timber with chloride of zinc.
2. Impregnation with copper or zinc sulphate.
3. Kyanizing—Impregnation with bichloride of mercury.
4. Creosoting—Impregnation with creosote or dead oil of coal tar.

In all these cases, the timber is heated, the sap vaporized, the air exhausted from the pores by means of a pump and the preservative forced into the pores under pressure.

5. Vulcanizing—In this case the wood is heated while under air pressure. The operation renders the sap insoluble and the timber durable.

24. What kind of timber resists decay longest under ground? Under water?

Under ground—Cedar, locust, chestnut, oak.
Under water—Palmetto wood of Florida.

25. Name the common kinds of stone used in building.

The more common building stones are granites, sandstones, slates, limestones and marbles.

26. What is hydraulic cement and how many kinds do you know of? What is the essential difference in their manufacture?

Cement which possesses the property of setting under water is called hydraulic cement.

There are three varieties of hydraulic cement: Portland cements, natural cements, and Puzzolana.

Portland is made of an artificial mixture of the ingredients ground, roasted and powdered.

Rosendale is prepared by calcining and powdering a natural stone.

Puzzolana does not require any roasting but is simply prepared by powdering the natural rock.

27. How would you test cements?

Cements are tested to determine their

1. Fineness.
2. Setting.
3. Soundness.
4. Specific gravity.
5. Strength.

1. Fineness is determined by passing the cement through sieves of various meshes and noting the percentages retained.

2. Setting is determined by making pats of the cement and noting the time before they resist penetration of wires of specified weight.

3. Soundness is tested by noting the condition of the edges of the pats; also by subjecting pats to a steam bath and observing if they blow, swell or crack.

4. Specific gravity is determined by weighing a given volume in air and noting the loss of weight when immersed in a liquid of a known specific gravity such as alcohol, which does not act upon the cement. Special apparatus is made for the purpose.

5. Strength is determined by preparing in moulds briquettes 1 sq. in. in section, permitting them to remain in air and under water specified periods and then breaking in testing machine, noting the breaking loads.

28. What is the meaning of the term "setting" as applied to cement?

Setting refers to the process of chemical combination which takes place among the particles of cement when subject to the action of water, resulting in its hardening.

29. What kind of sand should be used in mortar and how do you test its quality?

Sand for mortar should be fine grained, clean, sharp and free from loam, clay and other impurities.

Sand is tested for

1. Fineness—Determined by passing through sieves of known meshes and noting the percentages retained.

2. Cleanness—Tested by rubbing a sample between the fingers and noting if dust adheres to them.

3. Sharpness—Tested by examination with the aid of a lens.

4. Freedom from impurities.

Presence of salts is determined by adding nitric acid and nitrate of silver to a sample of the sand previously allowed to settle in distilled water. A white precipitate indicates the salt.

Clay is determined by permitting a sample to settle in water. The clay, if present, will separate in a distinct layer.

30. What is mortar composed of, and how mixed?

Mortar is composed of lime or cement mixed with sand and a sufficient quantity of water to make the mass plastic. The proportion of the ingredients depends upon their character and the purpose for which the mortar is to be used.

The sand and cement are spread dry in alternate layers in a mixing box or on a platform and turned repeatedly with shovels until the mixture appears entirely uniform, when it is spread out basin like, having a depression in the center into which the water is poured. By means of a hoe the dry mixture is then drawn into the water and worked until the ingredients are thoroughly incorporated and the mass uniform in character and of proper consistency.

31. Describe a good quality of brick and state how you would know a good brick from a poor one?

Good bricks are usually of dark reddish brown color, emit a clear ringing sound when struck, absorb a small percentage of water, do not crumble easily and do not scale or swell in water.

Poor bricks are reddish yellow in appearance, emit a dull sound when struck, absorb 15 to 25% of water, crumble easily and may scale or swell when left in water.

32. To what tests would you subject a brick to determine whether or not it was suitable for use in street pavements?

Bricks should be tested for

1. Resistance to crushing.
2. " " cross breaking.
3. " " abrasion or impact.
4. Porosity or absorbtive power.
5. General appearance, fracture, etc.

33. In how many ways is brick work bonded to make good work in heavy walls?

The usual bonds are:

1. Cross Bond—A course composed of headers and stretchers intervening. The joints in the second stretcher course come in the middle of the first.

2. English Bond—Alternate courses of headers and stretchers.

3. Flemish Bond—Headers and stretchers alternating in the same course.

4. Ordinary Bond—One header course following three or five successive stretcher courses.

34. Describe "rubble" masonry, "ashlar" masonry, and "broken ashlar" masonry.

Rubble is a class of masonry built of rough unsquared stones.

Ashlar refers to masonry built of stone blocks cut to regular figures and laid in courses usually of uniform height.

Broken ashlar refers to masonry built of cut stone not laid in regular courses.

35. Define the terms "quarry faced," "rough-pointed," "fine-axed," "bush-hammered" as applied to the dressing of stone.

Quarry faced refers to a class of masonry in which the surfaces of the stones are not dressed.

Rough pointed refers to surfaces of stones which have been dressed so that projections do not exceed ½ to 1 inch.

Fine axed refers to surfaces of stones which have been rough pointed and then finished with a "fine axe" having a specified number of blades to the inch.

Bush hammered refers to surfaces which have been rough pointed, fine pointed and then finished with a bush hammer.

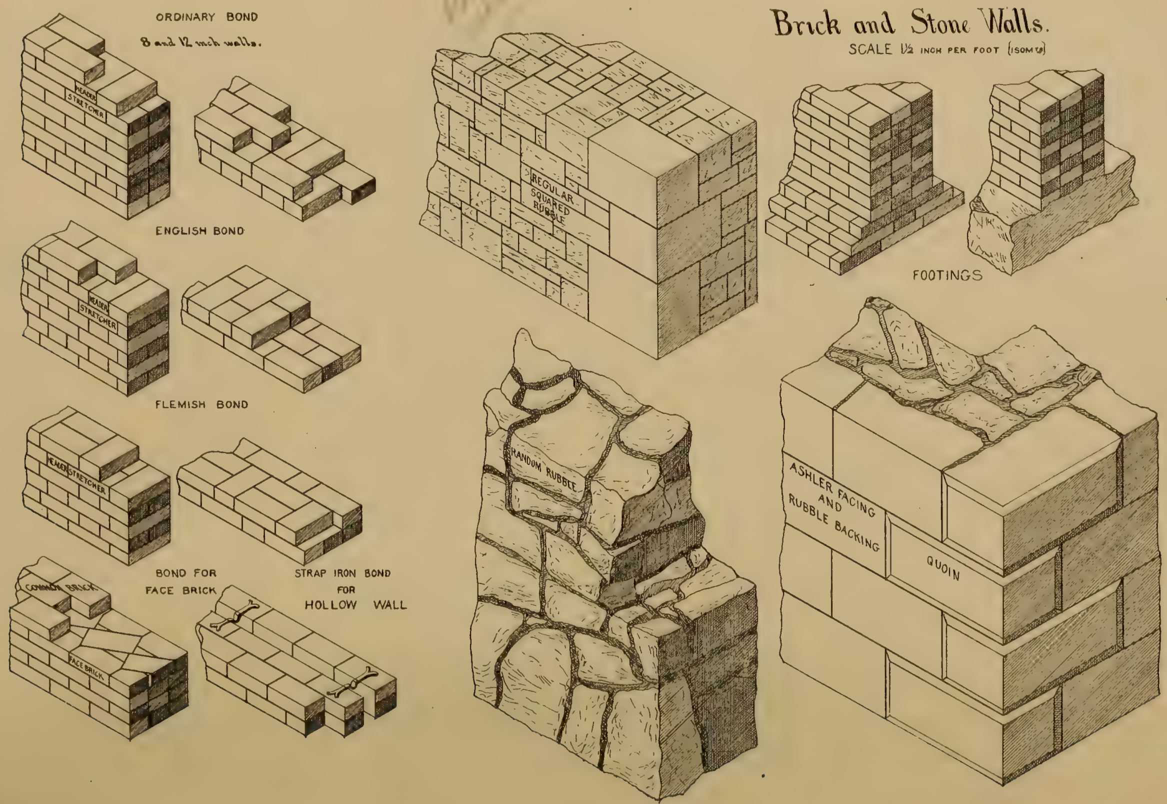
36. What are "headers" and "stretchers" as referred to masonry?

Headers are stones or bricks used for tying the face of a wall to the backing. They are set so that the greatest dimensions lie perpendicular to the face of the wall.

Stretchers refer to stones or brick which have their greatest dimensions parallel to the face of the wall.

37. What should be the proportion of "headers" to "stretchers"?

The proportion depends upon the character of the work. In brick work every sixth course should be a header.


Brick and Stone Walls.
SCALE 1½ INCH PER FOOT (ISOMT'C)
ORDINARY BOND
8 and 12 inch walls.
HEADER
STRETCHER
ENGLISH BOND
HEADER
STRETCHER
FLEMISH BOND
HEADER
STRETCHER
BOND FOR
FACE BRICK
COMMON BRICK
FACE BRICK
STRAP IRON BOND
FOR
HOLLOW WALL
REGULAR
SQUARED
RUBBLE
FOOTINGS
RANDOM RUBBLE
ASHLER FACING
AND
RUBBLE BACKING
QUOIN

In stone walls there should be one header to 3 stretchers or 1 header for each 12 square feet of wall surface.

38. Outline specifications for stone and laying of first-class ashlar granite masonry in a heavy retaining wall.

The cement should be the best quality Portland, and should meet all usual requirements when tested.

The sand must be clean, sharp, free from loam.

The stone must be first-class granite, uniform color, free from seams and other defects.

All stones must be cut to exact dimensions, the length not exceeding 4 times and the width not exceeding twice the depth.

All angles and arrises must be true, well defined and sharp.

Joints should be not more than $\frac{3}{8}$ in. wide and dressed to full depth of stone and properly broken in adjacent courses.

Courses should be well bonded longitudinally and transversely, there being at least one header to every three stretchers.

Face joints should be raked out for two inches before mortar has hardened and thoroughly pointed with 1 : 1 Portland cement mortar.

Plug holes should be at least 3 in. from arrises.

The dimensions will be taken as those of the least rectangle that will contain the stone.

The surfaces shall be rock-faced with $1\frac{1}{2}$-in. chisel draft at the arrises, cut on true lines.

The rock face should be bold, 3 to 6 in. beyond the arrises.

The stones should be laid on their natural bed and all joints full of mortar. Spawls may be used only to bring the stones level, but as few as possible are to go into the work.

When work is done in cold weather special apparatus to heat the sand and stone must be provided.

In hot weather the masonry should be protected and kept wet.

In joining old work to new special pains must be taken to secure a good bond.

39. What is concrete; of what composed, and in what proportion should its ingredients be mixed?

Concrete is artificial stone made by mixing sand, cement and broken stone or gravel with sufficient water to make the mass plastic.

The proportions of the ingredients to be used depend upon the character of the work and the nature of the ingredients themselves.

The usual proportions are—

1 cement, 2 sand, 3 stone.
1 cement, 2 sand, 5 stone.
1 cement, 3 sand, 5 stone.
1 cement, 3 sand, 6 stone.

40. (*a*) Upon what does the imperviousness of concrete to the passage of water depend? (*b*) Describe clearly and fully the method you would use to determine the best proportion of the several ingredients in order to make water-tight concrete?

(*a*) The imperviousness of concrete depends upon—

1. Character and proportion of the cement, sand, and stone, and the amount of water used.
2. Upon the thoroughness of the mixing.
3. Upon the care in laying and compacting.

(*b*) Provide a measure of known capacity, fill it with the sand to be used and then add water to the point of overflowing, noting the quantity, thus determining the per cent. of voids in the sand. In the same way determine the per cent. of voids in the stone. Now by starting with a barrel of cement as a unit, the quantity of sand which can be used for the mortar is determined from the known per cent. of voids: thus if the sand has 40% voids, 2½ barrels of sand may be used, giving 2½ barrels of mortar. The amount of stone can then be determined in the same way, thus if the voids in the stone are 50% there will be required 5 barrels of stone for each 2½ barrels of mortar, the whole making 5 barrels of concrete. The proportion will then be 1 volume of cement, 2½ volumes of sand and 5 volumes of stone; and for other percentages of voids will vary accordingly. Practically a little more cement than necessary to fill the voids should be added in mixing the mortar. Enough water should be used to make the mass plastic.

41. Describe method of making and laying concrete, stating what tests of cement should be made, how to select or secure good sand and stone, size of latter, the proportion of each with Rosendale or Portland cement and the manipulation of materials so as to secure good results.

Concrete is made by thoroughly mixing cement, sand and broken stone or gravel with a proper quantity of water.

The cement should be first class in quality, tested for fineness, soundness, specific gravity, setting, strength. The sand must be

clean, free from loam, and sharp. The stone must be clean, of varying sizes, but not too large (1 to 3 in.). The proportions may be—

With Portland cement	1:2:3 1:2:5 1:2:6 1:3:5 1:3:6
With Rosendale cement	1:2:3 1:2:5 1:3:6

The ingredients may be mixed by hand or by mechanical mixers in a variety of ways, but in all cases the important thing to be observed is that they are thoroughly incorporated in the mixture, which must be of proper consistency.

When mixed by hand, the cement and sand are first mixed dry on a platform, the water added, the resulting mortar spread out and covered by the stone in a uniform layer. The entire mass is then thrown with shovels, the water added until the desired consistency and uniformity are obtained. Measuring boxes should be provided for each ingredient and the specified proportions used. In depositing the concrete no opportunity should be given for the materials to separate or the water to drain off and carry the cement along. It should be deposited in irregular layers and compacted by ramming.

42. State briefly the important points regarding mixing (by machine) and placing heavy concrete masonry.

In mixing concrete by machinery the important points to be observed are—

1. That the specified proportions of the ingredients are fed into the mixer at all times.

2. That the quantity of water is uniform and of proper amount to produce the desired consistency.

3. That the ingredients are thoroughly incorporated before leaving the mixer.

4. That the entire contents of the mixer are taken out at each emptying.

5. When the mixer is stopped it should be flushed with water and no concrete partially set or otherwise should be permitted to remain in it.

6. The mixer should be located as near the work as possible.

7. The concrete should have a low fall when leaving the mixer, not giving the ingredients an opportunity to separate.

8. If transported the concrete must be carried in water-tight cars or barrows.

9. As soon as placed the concrete should be well compacted, all corners being thoroughly filled.

10. The forms must be firm, unyielding, have the closest possible joints and smoothed on the inside.

11. A richer concrete should be deposited near all exposed surfaces.

12. The work should be supervised by a competent inspector.

43. How many cubic yards of broken stone, sand and Portland cement will it take to make 100 yards of concrete,

3-in. broken stone having 50% voids.
2-in. broken stone having 40% voids.

The 2-in. stone will fill the voids of the 3-in. stone; the sand will fill the voids of the 2-in. stone; the cement will fill the voids of the sand; and 10 bbls. cement will make 1 cu. yd. What is the percentage of this mixture?

Assume that the sand has 40 per cent. voids.

10 bbls. of cement will fill the voids in 25 bbls. of sand.

25 bbls. of sand will fill the voids in $62\frac{1}{2}$ bbls. 2-in. stone (40% voids).

$62\frac{1}{2}$ bbls. of 2-in. stone will fill the voids in 125 bbls. 3-in. stone (50% voids).

For each cu. yd. of cement there will thus be required:

10 bbls. cement = 1 volume = 1 cu. yd.

25 bbls. sand = 2.5 volumes = $2\frac{1}{2}$ cu. yd.

$$\left.\begin{array}{l}62\tfrac{1}{2}\text{ bbls. 2-in. stone}\\ 125\text{ bbls. 3-in. stone}\end{array}\right\}=18\tfrac{3}{4}=\left\{\begin{array}{l}6\tfrac{1}{4}\text{ cu. yd.}\\ 12\tfrac{1}{2}\quad\text{``}\end{array}\right.$$

The resulting mixture will be $12\frac{1}{2}$ cu. yd. concrete.

For 100 cu. yd. concrete there will be required:

$8 \times 1 = 8$ cu. yd. cement.
$8 \times 2\frac{1}{2} = 20$ " sand.
$8 \times 6\frac{1}{4} = 50$ " 2-in. stone.
$8 \times 12\frac{1}{2} = 100$ " 3-in. "

The percentage of the mixture is $1 : 2\frac{1}{2} : 18\frac{3}{4}$.

44. What is rubble concrete and when is it used?

Rubble concrete is a mass of concrete in which are embedded blocks of rubble. It is used for large retaining walls, dams and foundations to save concrete and therefore decrease cost of the structure.

45. How would you proceed to determine the safe loads to apply upon piles in a given locality as calculated by the penetration, etc. In what way do piles act to uphold loads?

To determine the safe load, drive several test piles and record carefully the penetration at each blow of the hammer. When the penetration has become sufficiently small, so that the pile is near refusal, average the penetration of the last few blows and apply the ENGINEERING NEWS formula—

$$L = \frac{2\,w\,h}{s + 1}$$

L = Safe load that may be put on the pile (in lbs.).
w = weight of hammer in lbs.
h = height of fall in feet.
s = average set of last blows in inches.

Piles uphold loads by means of frictional resistance along their surface, also by acting as long columns supported at their lower end and carrying the load on top.

46. (*a*) What is the theoretical method of determining the safe bearing power of piles? (*b*) What modifications under different conditions? (*c*) Give practical method of determining the bearing power of piles.

(*a*) For the theoretical method see question No. 45.

(*b*) When the pile is driven to refusal in good material, the point resting on a hard stratum, the pile acts also as a long column and the safe load is accordingly increased.

When driven to refusal in soft mud, the bottom resting on a hard stratum, rendering the surface friction very small, the safe load should be computed by the column formula only, the friction being neglected.

The column is considered as having one pin and one fixed end and of a length equal to the exposed portion of the pile.

(*c*) To test the bearing power practically, drive piles to the required depth, upon them construct a platform and load the platform until the piles sink to refusal or until the desired penetration is reached. These observations will give the maximum bearing power directly, and by introducing a proper safety factor the safe load is obtained.

47. What is the safe load for a well-driven pile?

About 25 tons.

48. Describe briefly the several methods of sinking wooden piles and the conditions under which each would be used?

Wooden piles may be sunk:

1. By the ordinary pile-driver. An iron hammer weighing one to four thousand pounds is raised by machinery and permitted to fall upon the head of the pile. Used under almost all conditions.

2. By the steam hammer. In this case the hammer is operated by steam, the blows being light and rapid. Adapted especially in quicksands and soft soils.

3. By the water jet. An iron pipe is fastened to the side of the pile and lowered with it, the lower end of the pipe being near the point of the pile. Water is forced into the pipe causing a softening and loosening of the material below the point of the pile. The pile is forced into the material by the weight of the hammer resting upon it and by blows when necessary.

4. Piles may also be driven by utilizing the explosive force of gunpowder or dynamite, suitable apparatus being provided.

49. In driving piles through quicksand, which is the most effective method, a succession of quick, light blows or of slow, heavy ones? Give your reasons.

Quick, light blows are the most effective. The quicksand runs freely and exerts upward pressure on the pile, which tends to force it up. Quick, light blows will prevent this, and also prevent the sand from settling about the pile and thus increase the resistance to driving.

50. What is the best method of preserving piles in sea-water? In ground?

In sea water piles are best preserved by the creosoting process.

In the ground impregnation with creosote or with chloride of zinc are considered the best methods.

When piles are exposed to tide water they should be driven with the bark on, spruce or hemlock being commonly used. Where the teredo is active, the palmetto wood of Florida gives good results.

In firm soils, pines, oaks, elms or firs are used, the bark being removed.

51. Describe the various ways of shaping and using sheet piling to keep water from work in progress.

The sheet piles may be—

1. Tongued and grooved.
2. Overlapping.
3. Grooved only, with tongues driven in the grooves.

The ends of piles should be sharpened for driving.

Two rows of guide piles are first driven about 10 ft. apart. A pair of waling pieces are then fastened to the guide piles near their top leaving a space between waling pieces equal to thickness of the sheet piles. The sheet piles should be driven between the wales, starting at each guide pile working towards the center, the center pile forming a wedge to tighten the row. The point of the pile should be so sharpened that in being driven it will bear against the adjacent pile.

52. Bulk in place being assumed at 100, what would be the percentage in embankment for: loam, dry; loam, wet; loam, rolled; soft clay; stiff clay; sand; gravel?

The shrinkage in the embankments are—

For Loam, dry	12%
Loam, wet	10%
Loam, rolled	15%
Clay, soft	8%
Clay, stiff	10%
Sand	9%
Gravel	8%

53. How would you prepare the foundation for a heavy wall and how deep should it be excavated?

The foundation for a heavy wall should be excavated about 3 ft. and more if required by the character of the material or by the unit pressure on the foundation.

After excavation, the foundation should be freed from all foreign and decayed matter, the hollows and poor portions being replaced by good, firm soil or concrete. The bottom must be thoroughly wetted and compacted before the masonry is started. The trenches should be kept dry by pumping if necessary and any springs or fissures plugged up. If rock is encountered in the foundation it should be stripped of loose or decayed portions and benched or stepped, if too smooth.

54. Does the quality of cement, particularly Portland cement for hydraulic work, depend in any way upon its storage? (*a*) If so, state how it is affected by storage. (*b*) State what may be the

after effect upon a structure of lack of care in this respect. (*c*) Describe the proper storage of cement.

Yes.

a. Fresh cement has a certain amount of free lime which is removed by exposure to the air; fresh cement not having time to cool "swells" or blows."

b. Lack of care in this respect causes swelling of lime and subsequent disintegration of the masonry, thus endangering the structure.

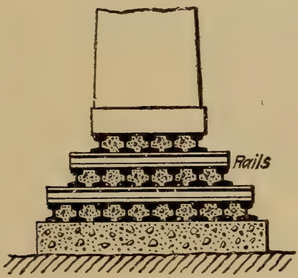
c. Cement should be stored in a dry enclosure, upon a platform raised a few inches above ground. It should be protected from rain or moisture by suitable covering.

55. How are walls founded on soft or yielding materials?

The material is excavated for two or more feet and piles driven to firm bearing, These piles are cut off at the same elevation, capped and a foundation bed of concrete deposited in the excavation around the pile heads or upon a platform erected on the piles. Upon this concrete the wall is built.

If the depth of the soft material is not very great the trench for the wall may be excavated to a hard stratum, and the excavation refilled with concrete to form the foundation bed.

The area of the foundation bed may be increased by grillage construction so that even in somewhat yielding material the unit foundation pressures may be made sufficiently low to give a stable wall.



56. In building a large sewer or portion of the aqueduct where quicksand is encountered, how would you proceed to get sound work? Under what conditions does quicksand of itself make a good foundation?

(*a*) In excavating for the foundation the width of the trench should be 2 to 4 ft. more than is required for the masonry. The sides should be very strongly braced by sheeting. Double wall lin-

ings should be used and provided with a cutting edge at the bottom, strongly braced between walls and filled with clay and sand. The excavation should proceed under the cutting edge, leaving a core at the center which is gradually removed with the sinking of the lining until a good foundation is secured. The excavation can be facilitated by forcing cement grout into the quicksand, solidifying the mass, or freezing the mass by the usual freezing process. When the proper depth is reached piles may be driven with butt end down into the underlying strata to solid bearing and the sewer built on the piles in the usual manner.

(*b*) When quicksand is so confined and drained so as to prevent flowing or displacement of same, it will make a safe foundation.

57. Discuss briefly the methods of handling quicksand in constructive work.

The methods commonly used to handle quicksand are:

1. By sheeting and bracing. The excavation should be made several feet wider than necessary to permit heavy sheeting to be put in. Above the quicksand the sheeting may be of the ordinary type, but heavy and firm. The sides of the excavation through the quicksand strata should be protected by double wall sheeting—constructed of two layers of timber filled with clay and provided with a cutting edge at the bottom to facilitate sinking. As the lining is sunk the core is excavated. (See previous question.)

2. By solidifying the quicksand with grout or cement. Pipes are sunk into the strata and grout or cement powder forced down under pressure, forming a mortar or concrete with the quicksand. By regulating the depths of the pipe any required mass can be solidified.

3. By the freezing process. A series of pipes 10 inches in diameter are sunk in a circle through the stratum of earth. Eight-inch pipes, closed at the bottom, are sunk inside the 10-in., and smaller pipes open at bottom are placed in the 8-in. pipes. A freezing mixture is then forced through one set of pipes, returning by the other, thus solidifying the surrounding mass of earth, which can then be removed in the usual way.

58. Where a street or railway in embankment crosses a stagnant pond the bottom of which is soft material, state what method you would pursue in making an earth fill across the same to obtain a permanent embankment.

Upon the bottom, over the embankment area, and for some distance outside, facines made of strong twigs and branches should be deposited. The twigs should be formed into bundles 6 to 12 ft. long

and 1 to 2 ft. thick, firmly bound together and made into mattresses. The bundles should cross one another to secure a homogeneous mass.

The mattresses are sunk by loading them with stone and the embankment material. The embankment should be built up sufficiently above the grade so that when settlement occurs the surface will be at or near the grade.

By means of the mattresses the weight of the embankment is distributed uniformly over a large foundation area, bringing the unit pressures within safe limits.

59. Describe clearly the usual method of tunneling in sound rock, where timbering is not required.

(*b*) How may the progress and cost of the tunnel be affected by carelessness of the contractor in blasting and otherwise?

(*a*) After the shaft has been sunk to subgrade, a heading about 6 ft. square is driven near the crown of the arch of the tunnel section. The drill holes are driven about 9 ft. in, and converging, so that the blast will remove a conical-shaped mass of rock. The sides are then taken out to the given lines.

Following this, holes are drilled in the shelf or bench thus formed, the heading meanwhile being carried forward. Care should be taken in blasting that the sides and top outside of the tunnel lines are not disturbed, and that adjoining property is not endangered. Loose or disintegrated rock outside of tunnel lines should be removed. After each blast the rock or spoil is removed to the surface. Water-bearing seams should be drained or grouted, and the tunnel kept dry by drainage and pumping.

(*b*) The contractor can delay the work by poor arrangement of drill holes, by using excessive charges, by not removing material systematically, by poor drainage, incompetent supervision, insufficient shoring and protective measures, carelessness in handling and storing explosives, &c.

60. How would you determine the size of a culvert to use?

The area of water-way may be determined—

1. By a careful examination and study of all openings under roads crossing the same stream.

2. By measuring the quantity of water flowing down the stream during heavy freshets.

3. By observing and studying the high-water lines as shown by the drift.

4. By computing the quantity of water reaching the culvert after a study of the character and extent of the drainage area, rainfall, etc.

$Q = c\ y\ \sqrt{S\ A^3}.$

Q = cu. ft. per sec. reaching culvert.

y = rate of rainfall, in inches per hour.

A = drainage area, in acres.

5. Myer's formula—

Area in Square Feet $= c\ \sqrt{\text{Drainage Area, in Acres.}}$

c is taken about 1 for rolling, open country.

1.5 for hilly ground.

4 for steep, rocky ground.

61. How would you guard against a wash-out?

A well or sump should be constructed at the entrance to the culvert, to receive heavy debris brought down during freshets. This sump, as well as the floor of the culvert, should be well paved. The capacity of the culvert should be sufficient to carry the water during the heaviest storms. Where the water is liable to back up, the embankment slope should be riprapped to prevent wash.

62. In the testing of elastic material, such as iron, what is the meaning of the term limit of elasticity, and about what proportion does the strength at that point bear to the total strength?

The limit of elasticity is that point up to which the ratio between the stress and corresponding strain is constant, and beyond which any additional load will cause permanent deformation, or it is the smallest load that will produce a permanent deformation.

The elastic limit is about one-half the ultimate strength.

63. What do you understand by limit of elasticity as applied to a beam under strain or pressure; what is meant by the neutral axis of a beam?

The limit of elasticity of a beam is the smallest unit stress that will produce a permanent deflection.

The neutral axis of the beam is the line along which there is no bending moment or strain.

64. For what parts of a structure may cast and wrought iron be used in reference to tension and compression?

Cast iron should be used in those members which are in compression and not subject to impact and heavy vibration. In these

cases and in all members subject to tensile stresses wrought iron should be used.

65. What are the ultimate and working strengths of a good quality of wrought iron per square inch?

Ultimate strength in tension	=	30 000 to 70 000 lb. per sq. in.
" " compression	=	40 000 to 120 000 lb. per sq. in.
" " shearing	=	40 000 to 60 000 lb. per sq. in.

Working stresses:

Tension....................	10 000—15 000 lb. per sq. in.
Compression................	30 000—40 000 lb. per sq. in.
Shearing...................	6 000— 9 000 lb. per sq. in.

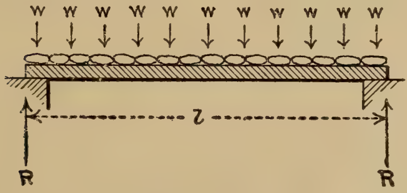
66. With the load uniformly distributed, what fractional part of the whole weight may be considered, in all calculations, as being carried at the center?

One-half the load is considered as carried at the center.

67. Suppose a uniformly loaded beam supported at both ends, and take w = unit weight, l = length of beam, b = breadth, d = depth, s = extreme fibre stress. Express algebraically the value of s in terms of the other quantities, and show how you obtain it.

The moment of the load at the centre $= \frac{w\,l^2}{8}$ = the resisting moment of the beam $= s\,\frac{I}{\frac{1}{2}d} = s \times \frac{1}{6}\,b\,d^2$.

$$\frac{w\,l^2}{8} = \frac{s}{6}\,b\,d^2, \text{ or } s = \frac{3}{4}\,\frac{w\,l^2}{b\,d^2}$$



68. What proportion of the breaking weight of a beam would you consider a safe load?

For iron beams about $\frac{1}{5}$th.
For wooden beams about $\frac{1}{10}$.

69. Sectional area being 36 sq. in. which would be the stronger section, 6 x 6 or 4 x 9?

The strength of a beam increases with the square of the depth, but only with the first power of the width.

The 4 x 9 beam will, therefore, be the stronger, the strength compared to the 6 x 6 being

as $4 \times 9^2 : 6 \times 6^2$, or as $3 : 2$.

70. Describe what is meant by "shear" in computing bridge stresses and state in general how it is obtained.

The shear at any section is the algebraic sum of all the forces on one side of the section; it is the total force tending to move one portion of the member past the other at the section in question.

It is obtained by taking the algebraic sum of all the external vertical forces acting on either side of the section, including the reaction.

71. What is the angle of repose as applied to earth, and what relation does it bear to the angle of maximum pressure?

It is the angle with the horizontal made by the freely sloping surface of a mass of earth.

The angle of maximum pressure is taken to bisect the angle made by a vertical plane and the plane of repose of the earth backing, *i. e.* it is equal to $\frac{1}{2}$ (90°—angle of repose).

72. At what point above the base of a retaining wall will the center of pressure from earth behind it be located, when the earth is level with the wall?

The center of pressure is at a distance above the base equal to one-third the height of the wall.

73. What are the conditions of the stability of a retaining wall?

Theoretical conditions:

1. The unit pressure on the foundation bed must not exceed the safe bearing power of the underlying material.

2. The unit pressure on any portion of the masonry must be within safe limits.

3. To insure stability of the wall against sliding on its base or along any horizontal line—the weight of the wall above the line multiplied by the coefficient of masonry friction must ex-

ceed the horizontal pressure at that point, produced by the backing.

4. To insure stability against overturning about the toe, the moment of resistance about the toe of the wall due to its weight should exceed the overturning moment due to the backing. This condition will be satisfied if the line of resultant pressure falls within the middle third of the base.

5. The foundation should be constructed, the backing properly laid and drained so that the conditions and data considered in the design will not materially change after the wall has been constructed.

74. In what ways do retaining walls fail?

Retaining walls may fail:

1. By excessive or unequal settlement of the foundation.

2. By disintegration of the masonry, caused by its poor quality or bond, or excessive unit pressures.

3. Heaving of the wall due to frost caused by improper drainage of backing.

4. By "bulging" or sliding along the base or some horizontal line, owing to the excessive horizontal thrust of the backing.

5. By overturning about the toe owing to the insufficient weight of the wall or thickness of the base.

75. In case of retaining wall, at what angle will the earth sustain rupture in case of the movement of the wall?

The earth will first rupture along the plane of maximum thrust and eventually along plane of natural slope.

76. What precautions should be taken in building a retaining wall?

The excavation should be carried down to a satisfactory foundation bed.

The bottom should be freed from all perishable matter, which should be replaced by firm soil or sand, watered and rolled.

The heaviest courses should be laid at the bottom.

The masonry should be well laid and securely bonded horizontally and vertically, frequent headers being used and spawls avoided as much as possible.

Drainage should be provided for by means of weep holes or drains laid along the heel of the wall. A layer of gravel should be placed adjacent to the wall to drain the backing.

In depositing the backing the earth thrust will be decreased with the increase of compactness of the material.

The bed joints of the masonry in the interior of the wall should if feasible incline normal to the direction of the resultant thrust.

77. Without increasing the dimensions of a retaining wall, what precautions, in filling behind it, will increase its safety?

The thrust of the backing will be decreased and the safety of the wall increased by depositing the backing in thin compact horizontal layers watered and rolled.

A layer of gravel or loose material laid adjacent to the back of the wall will facilitate drainage of the backing and minimize the effect of frost.

78. In designing a retaining wall for a street where it crosses a valley by an embankment, how would you proceed to determine its dimensions? Show by diagram the position and direction of the resultants of the force acting in a well-designed retaining wall.

The grade at which the street is to cross the valley is usually known, and the surface elevations along the line of the wall are given by the surveys. The difference between the street grades and the original surface elevation gives the depths of the wall at various points along the line. The top width of the wall is assumed from 3 to 6 feet, according to the depth. With good masonry, the thickness at the base can then be made $\frac{1}{3}$ to $\frac{1}{2}$ of the height, and the wall carried down to a good foundation. The face of the wall is battered and the back stepped off to make a good bond with the backing. With the assumed dimensions the theoretical conditions of stability can be investigated by the usual force diagram and the thickness increased or decreased, as economy and practical considerations dictate.

In computing the thrust the moving load, on the street within the range of the prism of maximum thrust, should be taken into account.

79. Outline the principal steps required in the theoretical design of a retaining wall.

1. The height of the wall is usually given by the conditions of the problem.

2. Assume a trial thickness on top equal to about $\frac{1}{4}$ of the height and about 0.4 the height of the bottom; give the face of the wall a batter and assume the back vertical.

3. Plot the wall to scale, using the trial dimensions.

4. Draw the lines of the earth slope and line of maximum thrust.

5. Compute the weight of the maximum earth prism, earth weighing 110 lb. per cu. ft. and the thrust which equals about 0.64 of this weight.

6. Compute the weight of the wall, assuming a unit weight of 150 lb. and the position of its center of gravity.

7. Draw the line of thrust to scale, making an angle with the normal to the back of the wall equal to the angle of repose and passing through the center of pressure.

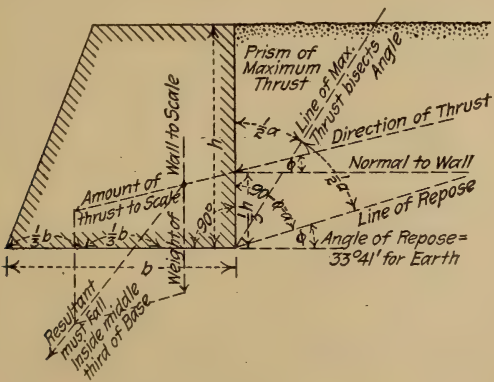
8. Draw the line representing the weight of the wall to same scale, passing through the center of gravity.

9. Combine these forces and plot their resultant to insure that there is no tension in the joints at the back of the wall, this line of pressure should fall within the middle third of the base.

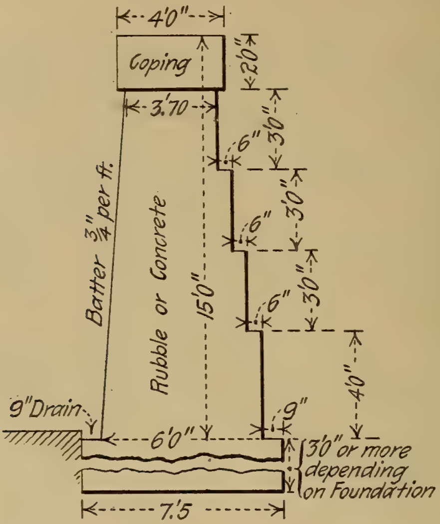
10. Compute the resisting moments of the weight of the wall and the overturning moment of the thrust, taken about the toe. The resisting moment should be larger by four or five times the overturning moment.

11. Compute the horizontal component of the thrust at the base and at some distance above it, and also the frictional resistance to sliding at these points. The latter should be three or four times as great as the former.

12. If these conditions are not satisfied by the assumed dimensions, increase or decrease the latter, as may be required for safety or economy.



80. What should be the thickness at the top and base of retaining wall 15 ft. high, built to retain ordinary earth? Show a sketch of the wall, and how it should be founded.



81. What is the condition of arch sliding at the springing line and in what form of arch is this most likely to occur?

The arch will slide when the component of the pressure on the springing line parallel to the joint at that point is greater than the friction between the two surfaces of the joint.

This is most liable to occur in flat or segmental arches.

82. Outline the steps taken to find the thickness of an arch of stone, span and rise being given?

1. Obtain a trial depth of keystone by Trautwine's formula,

$$t = \frac{\sqrt{r + \frac{1}{2} s}}{4} + 0.2$$

Where t = thickness at the crown, in feet.

s = span of arch, in feet.

r = rise of arch, in feet.

2. Plot the arch to scale, using the given and assumed dimensions.

3. Calculate from given data the loading on the arch and find the horizontal thrust at the crown.

4. Divide the arch ring and material above it into sections by vertical planes.

5. Compute the position of the center of gravity for each section.

6. Compute the load supported at each section, reducing various classes of loading to equivalents having a common weight.

7. Find, graphically, the position of the resultant of the thrust at the crown, and the weight of the arch and spandrel, etc., of the adjacent section.

8. Combine the resultant thus formed with the weights of the next section.

9. Continue until the position of the resultant pressure is determined for each section, giving the line of pressure for the entire ring.

10. To insure stability the line must fall within the middle third of any section of the arch ring.

If the line falls outside of this, the assumed trial depth must be increased.

If, however, it follows very closely the center line of the arch, the thickness may be decreased for economy.

11. The unit pressure on the masonry of the arch ring should also be computed to insure that it does not exceed proper working limits.

12. New positions of the resultant should be found for the new thickness determined upon until the most economical section consitent with safety is found.

83. (*a*) How would you design the base of abutment of an arch?

(*b*) Suppose abutment to be built on compressible ground, give sketch of foundation you would use, and give reasons for each step.

1. Find the thickness of the abutment at the spring line tentatively by Trautwine's formula:

$$t = \tfrac{1}{5}\,r + \tfrac{1}{10}\,s + 2 \text{ ft.} \quad \begin{cases} t = \text{thickness, in feet.} \\ r = \text{rise of arch.} \\ s = \text{span, in feet.} \end{cases}$$

2. Give the outer slope of the abutment a batter equal to $\frac{1}{24}$ the span and make the inner face vertical.

3. Carry the batter down to the foundation, compute the bottom width and calculate the unit pressure of the foundation bed. This should be within safe limits—if the bearing power is small, a grillage of steel and concrete or concrete alone may be used to obtain a sufficient area to bring the pressures within

limits—if the amount of excavation and masonry required becomes excessive, piles may be used to support the abutment.

4. The position of the line of pressure in the abutment should fall within the middle third of any horizontal section.

This position at the springing can be determined graphically by combining the resultant thrust of the arch with the weight of the abutment above it, and for any horizontal section below the springing, combine the resultant already found with the weight of the additional portion of the abutment to that point.

84. What is a flush tank, and state its uses?

A flush tank is a device for periodically flushing a sewer by automatically and rapidly discharging a large quantity of water into it. It is usually placed at dead ends of sewers, where material is apt to collect.

It is an essential feature of the separate system in which no storm water is permitted to reach the sewers. The water for operating the tank is supplied by the regular mains.

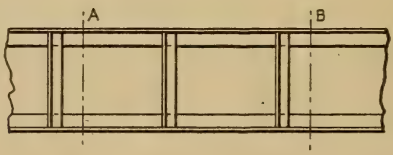
85. What is the best bond for brick sewers?

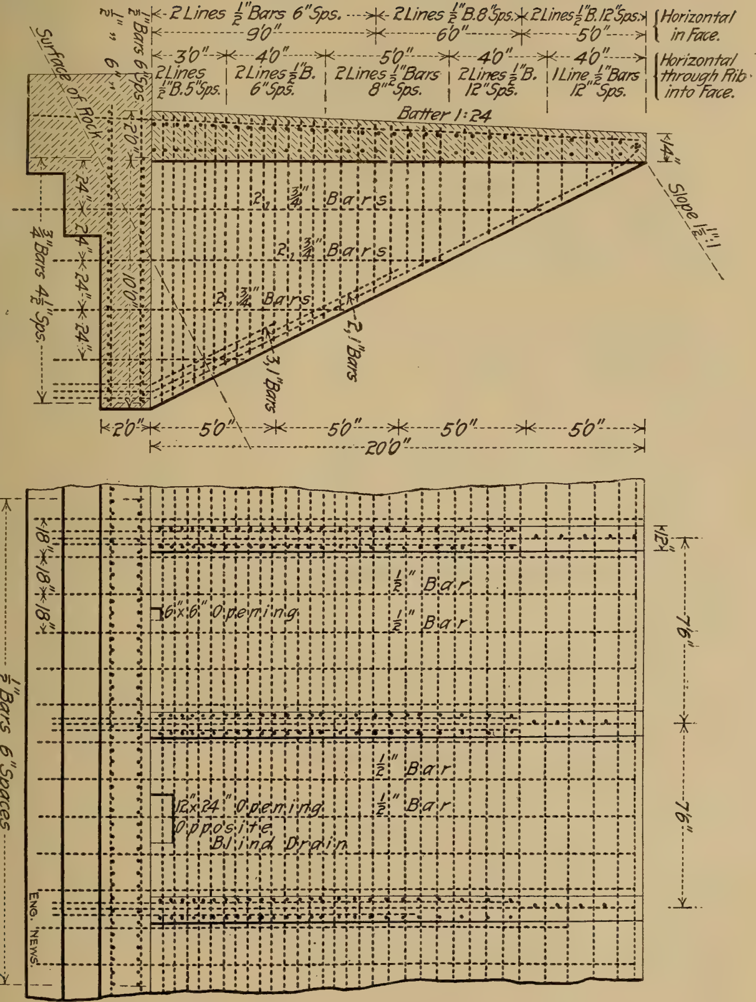
The best bond is the rowlock bond, which consists of concentric rings, each longitudinal course breaks joints with the adjacent courses and with the rings above and below. All bricks are laid as stretchers.

86. Sketch a concrete retaining wall reinforced by steel.

See page 77.

87. Describe clearly the method you would pursue to arrive at the proper number and spacing of the rivets in the flanges of a plate girder.





Section and Elevation of Concrete Steel Retaining Wall.

F_2 = flange stress at B.
Let F_1 = flange stress at A.
b = smallest bearing value of 1 rivet.
s = smallest shearing value of 1 rivet.
n = number of rivets required in each flange between A and B.

Then

$$n = \frac{F_1 - F_2}{b}$$

If s is smaller than b, we have

$$n = \frac{F_1 - F_2}{s}$$

To get the flange stress at any point, divide the bending moment at that point by the effective depth of the girder.

88. Given a roof truss with rise equal to one-third of span, span equal to 50 ft., trusses 16 ft. apart, total load over the whole surface 30 lb. per sq. ft. of horizontal projection. Design the truss.

Assume outline of truss, as shown.
Total load on truss $= 16 \times 50 \times 30 = 24\,000$ lb.
Panel load $= \frac{24\,000}{8} = 3\,000$ lb.

Draw stress diagram as shown; it is not necessary to complete the whole diagram for symmetrical trusses with uniform vertical loading. The hanger EE is not a member of the truss, and therefore does not appear in the stress diagram.

Allow 800 lb. per sq. in. in compression on yellow pine timber.
Allow 1 200 lb. per sq. in. in tension on yellow pine timber.
Allow 12 000 lb. per sq. in. in tension on wrought iron.

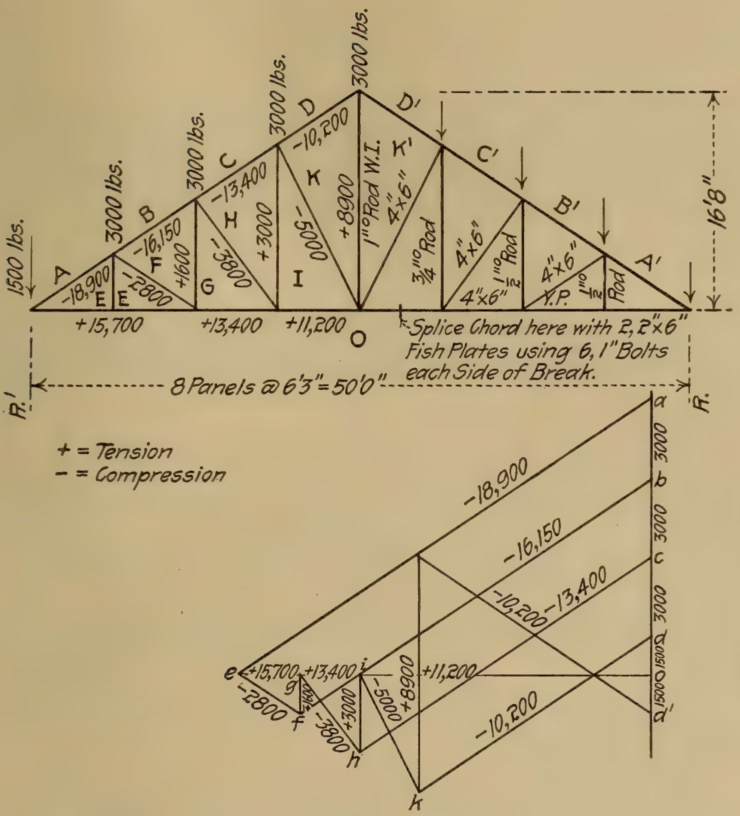
$A\,E$, $\frac{18\,900}{800} = 23.6$ sq. in. required. Use 1-6-in. x 6-in yellow pine timber for whole length of rafter. This allows for cutting.

$E\,O$, $\frac{15\,700}{1\,200} = 13.1$ sq. in. required. Use 4-in. x 6-in. yellow pine for whole bottom chord, in two lengths, spliced near center.

$K\,I$ $\frac{5\,000}{800} = 6.3$ sq. in. required. 2 in. x 3 in. would do; 4 in. x 6 in. is better, making $\frac{l}{d} = 42$.

$K\,K^1$ $\frac{8\,900}{12\,000} = 0.74$ sq. in. required. Use 1-in. round rod with ends upset.

$H\,I$, $\frac{3\,000}{12\,000} = 0.25$ sq. in. required. Use $\frac{3}{4}$-in. round rods with ends upset.

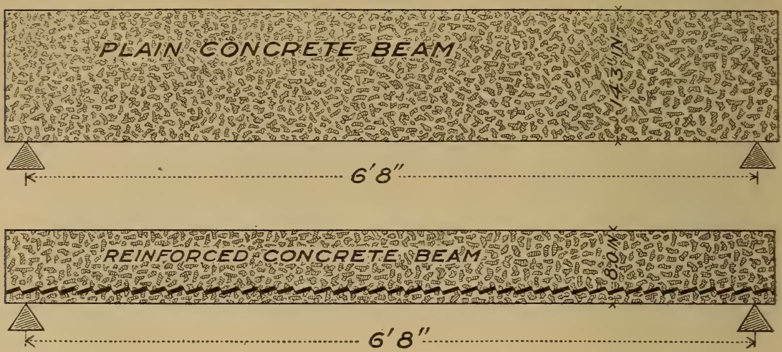


$F\,G,\ \dfrac{1\,600}{12\,000} = 0.13$ sq. in. required. Use ½-in. round rods, with ends upset.

89. Discuss the use of the reinforced concrete and explain the design of a reinforced concrete girder?

The resistance offered by plain concrete to tensile and shearing stresses is so small and unreliable as to practically prohibit its use, with economy and safety, in structures subjected to the stresses mentioned. The discovery that concrete may be reinforced with metal so as to largely increase the resistance to tensile and shearing stresses has entirely overcome the serious objection mentioned and greatly extended the scope of application. Introducing the metal converts a practically inelastic body into one possessing elasticity in addition to durability, increasing strength with age, rust-proof and fire-resisting qualities, susceptibility to rapid and economical execution, pliability to various forms, and also

innumerable æsthetic possibilities. The sections shown represent a plain concrete beam and one reinforced with 1% of metal.



The fundamental principle of design may be stated as follows: In any structural member, mortar or concrete, reinforced by metal, is capable of sustaining very much greater elongations than when not reinforced and still effectually contribute to the resistance of the member.

Concrete and steel have the same coefficient of expansion; there is thus no tendency of the material to separate with change of temperature.

The adhesion of concrete to steel is found to exceed 500 lb. per sq. in.

Hyatt and Johnson formulæ.

Assumptions:

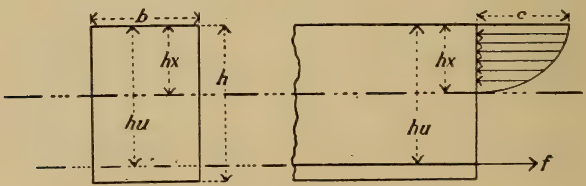
1. Sections plane before bending remain plane surfaces, therefore the distortion of any fibre is proportional to its distance from the neutral axis.

2. The applied forces are perpendicular to the neutral surface.

3. The values of the moduli of elasticity obtained in direct tension and compression apply to the material under stress in beams.

4. There is no slipping between the concrete and the metal.

5. There are no initial stresses in the beam due to contraction, etc.



Let h = height of beam in inches, and
b = breadth of beam in inches.
hx = distance of compression face from neutral axis.
hu = distance of compression face from center of gravity of metal.
p = ratio of area of steel to area of concrete $= \frac{As}{Ac}$.
c = compressive stress in extreme fibre of concrete.
f = tensile stress in steel.
Es and Ec = moduli of elasticity of steel and of concrete in compression respectively.

x, u and p are ratios.

Equating the tensile and compressive forces of the cross-section we have:

$\frac{2}{3}\, cx = pf$ ....(1).

According to the first assumption $\frac{c}{Ec} : \frac{f}{Es} :: hx : h\,(u—x)$ and by substitution equation (1) becomes $\frac{2}{3}\,x^2 = \frac{Es}{Ec}\,(u—x)\,p$, from which

$$x = -\frac{3}{4}\,\frac{Es}{Ec}\,p + \sqrt{\frac{3}{2}\,\frac{Es}{Ec}\,p\left(u + \frac{3}{8}\,\frac{Es}{Ec}\,p\right)} \quad \ldots\ldots\ldots\ldots (2)$$

Finally, taking moments about the neutral axis, the resisting moment is:

$$M = b\,h^2\left[\tfrac{5}{12}\,c\,x^2 + p\,f\,(u - x)\right] \quad \ldots\ldots\ldots\ldots\ldots (3)$$

$M = \frac{2}{3}\,cx\,(u—\frac{3}{8}x)\,bh^2$ if allowable stress in concrete is assumed
$M = pf\,(u—\frac{3}{8}x)\,bh^2$ if allowable stress in steel is assumed ..(4)

bh^2 in equation (4) may be replaced by K, "a numerical coefficient depending for a given u and $\frac{E_s}{E_c}$ simply on the steel percentage and can be taken from a table." If u be assumed as unity, remembering that the value of h resulting from this assumption is the distance from the top of the beam to the center of gravity of the reinforcement, and that the actual deph of the beam is obtained by adding a sufficient thickness of concrete below the metal for its complete protection.

Working formulæ:

$$\frac{2}{3}\,c\,x = p\,f \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (5)$$

$$x = -\frac{3}{4}\,\frac{E_s}{E_c}\,p + \sqrt{\frac{3}{2}\,\frac{E_s}{E_c}\,p\left(1 + \frac{3}{8}\,\frac{E_s}{E_c}\,p\right)} \quad \ldots\ldots\ldots (6)$$

$$M = K\,b\,h^2 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (7)$$

Where $K = \frac{2}{3}\,c\,x\left(1 - \frac{3}{8}\,x\right)$ or $pf\left(1 - \frac{3}{8}\,x\right)$, depending

upon whether the allowable unit stress for concrete or steel is assumed. The relation of the two is determined from equation (5) and neither must be exceeded.

The constants to be assumed are p, $\frac{E_s}{E_c}$, c or f; p is optional and the remainder depend upon the nature of the materials.

In the design of unreinforced masonry structures (arches, retaining walls, dams, etc., no tension is permitted to develop in the joints. When these structures are reinforced this condition is not necessary and their sections can therefore be reduced. The line of pressure may fall outside of the middle third and yet the structure be theoretically stable.

90. Give the usual form for an intermediate monthly estimate.

(See p. 83.)

AQUEDUCT COMMISSION AND WATER SUPPLY.

91. Describe in a general way the water supply system of the Borough of Manhattan, Bronx and Brooklyn, giving, as far as you know them, the character, area of watershed and description of reservoir.

The Borough of Manhattan receives its supply from the watershed of the Croton River, having an area of 360+ sq. miles.

The water is impounded in a number of reservoirs, the principal dams being the New and Old Croton Dams, Titicus, Amawalk, Sodom, Bog Brook and Carmel.

Two Aqueducts (the old and the new) of a combined carrying capacity of about 400 million gallons daily, having inlets at Croton Lake, deliver most of the water to the distributing reservoirs at Central Park, a portion being diverted at One Hundred and Thirty-fifth Street gate house for distribution. The old aqueduct is about 38 miles long, 53+ sq. ft. in section and at Ninety-second Street changes to three 48-in. pipes to reservoirs. The new aqueduct is masonry, 155+ sq. ft. section, to the Harlem River crossing, which is a steel siphon, and at One Hundred and Thirty-fifth Street changes to eight 48-in. pipes, four leading to Central Park Reservoir and four connecting with city mains. Water is pumped from the distributing reservoir for low and high service. In addition to the Croton, the watershed of the Bronx and Byram Rivers is used, having an area of 22 sq. miles. Collecting the water at the Kensico Reservoir and delivering the water to the Williamsbridge Reservoir by means of a 48-in. pipe for distribution to the Bronx.

The new reservoir at Jerome Park will give an additional storage of 7 billion gallons. The entire storage system available

Typical Form for Monthly Estimate.—90 Per Cent. Payment

THE CITY OF NEW YORK. Estimate No........................

To...Dr.

For work measured and estimated in constructing..., under a contract dated...from ....1. , to..1, .

Total Quantities Estimated to Date Including Present Estimates.	Total Quantities Previously Estimated.	Approximate Quantities Measured and Estimated for above Month.			Description of Work Done.	Unit Prices.	Monthly Amounts. Dollars.	Monthly Amounts. Cts.	Total Amounts. Dollars.	Total Amounts. Cts.
2 000	1 000	1 000		cubic yards	Removal of soil taken from spoil banks, including all work incidental thereto.	0.30	300	00	600	00
2 000	1 000	1 000	*aa*	square yards	Sodding, including all work incidental thereto.	0.20	200	00	400	00
2 000	1 000	1 000	*b*	cubic yards	Earth excavation, including the disposal of it, and all work incidental thereto.	0.30	300	00	600	00
2 000	1 000	1 000	*c*	cubic yards	Rock excavation, including the disposal of it, and all work incidental thereto.	2.00	2 000	00	4 000	00
2 000	1 000	1 000	*e*	M. ft. B. M.	Permanent timber work, placed and fastened, including all work incidental thereto.	55.00	55	00	110	00
2 000	1 000	1 000	*f*	barrels	Portland Cement, in barrels of 400 pounds, ordered by the Engineer, and placed in the work, including all work incidental thereto.	2.50	2 500	00	5 000	00
2 000	1 000	1 000	*g*	cubic yards	Concrete masonry in place, formed of five parts of broken stone, or gravel, or a mixture of both, to one part of cement, and made with American Cement Mortar mixed in the proportion of one part of cement to two parts of sand, including all work incidental thereto.	4.00	4 000	00	8 000	00
2 000	1 000	1 000	*h*	cubic yards	Brick masonry, not included in item (*h h*), laid in American Cement Mortar mixed in the proportion of one part of cement to two parts of sand, including all plastering and pointing, all scaffolding, centers, forms, etc., and removing the same, and all work incidental thereto.	9.00	9 000	00	18 000	00
2 000	1 000	1 000	*i*	cubic yards	Rubble stone masonry, laid in American Cement Mortar mixed in the proportion of one part cement to two parts of sand, including all work incidental thereto.	3.00	3 000	00	6 000	00

Total amount estimated			$42 700	00
Total amount previously estimated			21 355	00
Total amount of present estimate			$21 355	00
Total amount of work measured and estimated between the above dates	$21 355	00		
Deduct 10 per cent	2 135	50		
Balance due for work measured and estimated during the month	$19 219	50		

I hereby certify that this is a just estimate of the approximate amount of work measured and estimated between the............and........ days of ....190.. both inclusive.

Chief Engineer,

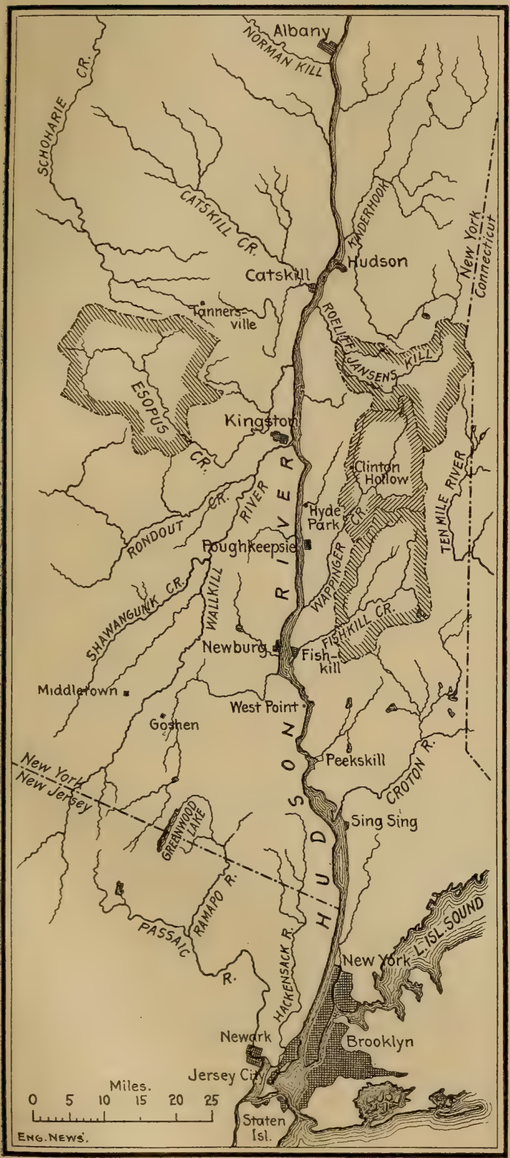
for Manhattan and Bronx will then be in the neighborhood of 75 billion gallons.

Brooklyn derives its supply from underground sources. A large number of driven wells are connected to pumping stations and the water is delivered to conduits which conduct it to distributing reservoirs at Ridgewood (capacity 400 million gallons) and Prospect Park (capacity 20 million gallons). There is also a storage reservoir at Hempstead having a capacity of 1 billion gallons. Pumping stations are located at the driven-well areas, such as Spring Creek.

92. Name the watersheds available for supply of the City of New York, and state briefly the advantages and disadvantages of each.

Watersheds or sources of supply.	Drainge area in square miles.	Estimated daily capacity, million gallons.	Draft on drainage area, inches per annum.	Storage Provided.		Remarks.
				Million gallons.	Days' supply.	
Croton River......	360	280	16.3	75 000	268	Near the City; water fairly good.
Fishkill River.....	81	60	15.6	16 800	280	Nearer than the Catskills; high; water somewhat hard.
Esopus Creek.....	255	280	21.4	66 500	256	Water pure and soft.
Rondout	120	....	....	20 000	....	Water pure and soft.
Wappinger Creek.	116	80	14.5	30 500	381	Water fairly hard; nearer than Catskills.
Roeliff Jansen Kill.	149	100	14.1	17 200	172	Water somewhat hard; nearer than Catskills.
Catskill Creek....	160	....	....	14 000	....	Water good.
Schoharie Creek...	228	....	....	65 000	....	Water good; shed partly in Mass.
Long Island underground water-shed.	....	100	....	....	....	Water very fine.
Hudson River.....	....	Unlimited.	....	....	....	Water polluted; requires pumping and filtration.
Adirondack	....	....	....	....	....	Water good; too far away.
Ten Mile River....	....	....	....	....	....	Water good; partly in Conn.
Housatonic River.	....	....	....	....	....	Water good; partly in Conn.
Walkill River......	....	....	....	....	....	Water fair; partly in N. Jersey.

NOTE.—See *Engineering News*, October 1, 1903, for brief, but concise, description of the work of Commission on Additional Water Supply.


Albany
NORMAN KILL
SCHOHARIE CR.
CATSKILL CR.
KINDERHOOK
Hudson
Catskill
New York
Connecticut
Tannersville
ROELIFF JANSENS KILL
ESOPUS CR.
Kingston
RIVER
Clinton Hollow
TEN MILE RIVER
RONDOUT CR.
RIVER
Hyde Park
Poughkeepsie
WAPPINGER CR.
SHAWANGUNK CR.
WALLKILL
FISHKILL CR.
Newburg
Fish-kill
Middletown
West Point
Goshen
Peekskill
New York
New Jersey
CROTON R.
HUDSON
GREENWOOD LAKE
Sing Sing
RAMAPO R.
PASSAIC R.
HACKENSACK R.
L. ISL. SOUND
New York
Brooklyn
Newark
Jersey City
Miles.
0 5 10 15 20 25
Staten Isl.
ENG. NEWS.

93. What is the fundamental law or equation upon which the flow of water in pipes, conduits, etc., is based, and what modifications in it are necessary when applied to particular cases?

$Q = A\ v = A\sqrt{2gh}$,
A = area of cross-section of pipe, channel, etc.,
v = velocity in feet per second,
g = 32.16, the acceleration due to gravity,
h = head of water in feet.

For orifices, weirs, conduits, etc., this is modified by the introduction of constants or factors depending upon their size, condition of surfaces, shape, etc.; the actual velocity and discharge always being less than the theoretical.

The following are the formulas most commonly used:

For orifices, $Q = c\,A\,v = c\,A\sqrt{2\,g\,h}$, c varying from about .60 to .9.
For short pipes (length = 3 diameters).

$$Q = c\,A\,v \qquad c = .80\pm$$

For weirs, $Q = c\,L\,h^{\frac{3}{2}}$ $c = 3.33$.

For long pipes, $Q = A\sqrt{\dfrac{2\,g\,h}{1.5 + \dfrac{f\,l}{d}}}$, $f = 0.02$ (trial value).

For open channels or very long pipes, use the Chezy formula $Q = c\,A\sqrt{rs}$; in which c,

by Kutter's formula $$c = \frac{\dfrac{1.811}{n} + 41.6 + \dfrac{.00281}{s}}{1 + \left(41.6 + \dfrac{.00281}{s}\right)\dfrac{n}{\sqrt{r}}}.$$

Notation:

c constant found by experiment,
A cross-section area of channel, etc., in square feet,
L length of crest of weir in feet,
f friction factor found by experiment,
I length of pipe in feet,
s sine of slope of water surface,
d diameter of pipe in feet,
r mean hydraulic radius,
n constant depending on roughness of surface.

94. State the principle (*a*) of the pressure of water; (*b*) of the siphon.

(*a*) There is no internal friction among the molecules of water. The surface of still water will therefore always be level. The pressure of the water is equal in all directions.

The amount of the pressure at any point depends upon the head of water and acts normally to the surface pressed. It is equal to the area of the surface times the head of water on its center of gravity.

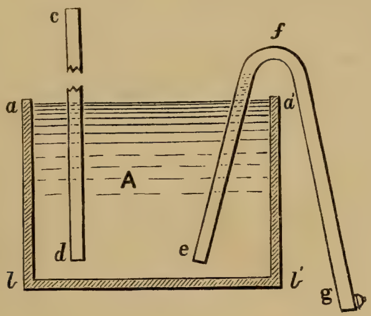
(*b*) The siphon acts as follows:

On the outlet of the siphon there is a pressure of water equal to its difference of elevation from that of the inlet.

On the surface of the water there is an atmospheric pressure of 15 lb. to the square inch.

When a vacuum is formed at the outlet, the unbalanced atmospheric pressure at the inlet causes the water to rise into and down the siphon and then discharge.

After the flow has begun the difference in hydrostatic pressure between the inlet and outlet keeps the flow continuous until the water level has decended below the inlet. If the flow into the siphon is continuous, the discharge will also be.



95. What is the center of pressure? How would you find it for a rectangular gate immersed in water?

The center of pressure is the point at which a single resultant force applied to replace a system of forces will produce the same effect as the latter. A force opposite in direction and equal in amount to the system of forces applied at this point, will hold the body in equilibrium.

If d = distance of center of pressure to *bottom* of the gate,
h_1 = head of water on bottom of gate,
h_2 = head of water on top of gate,

Then $d = \frac{1}{3}\left(\frac{h_2^3 - h_1^3}{h_2^2 - h_1^2}\right)$. If $h_2 = o$, $d = \frac{1}{3}h$.

The total pressure on the gate as equal to its area multiplied by the head of water on its center of gravity, times the weight of 1 cu. ft. of water.

$$\text{Or } P = \text{Area} \times \tfrac{1}{2}(h_1 + h_2) \times w.$$

If $h_2 = 0$, that is, the top of the gate is level with the surface,

$$P = \text{Area} \times \tfrac{1}{2} h. w.$$

For a width of 1 ft. of gate area $= 1 \times h$ and $P = h \times \frac{1}{2} wh = \frac{1}{2} wh^2$.

96. What do you mean by the grade line of a pipe and its hydraulic grade line? What relation should exist between them?

The grade line of the pipe indicates the rate of rise or fall along any portion of the pipe *as laid.*

The hydraulic grade line indicates the fall in the pressure head along the pipe. It is the line connecting the water level in piezometer tubes placed at various points along the pipe.

The grade line of the pipe should never, if possible, rise above its hydraulic grade line, for the pressure of air collecting in the summit will diminish the flow.

97. In a rectangular dam, where is the center of pressure? Where should the line of pressure on an arch fall?

a. At two-thirds of the depth of water below the surface.
b. In the middle third of any section of the arch ring.

98. What is the pressure against the vertical face of a dam for a space one foot wide and a depth of one foot below the surface?

The pressure against the face $= 62.5 \times 1 \times \frac{1}{2} = 32.25$ lb.
Intensity of pressure 1 ft. below surface $= 62.5$ lb.

99. What is the pressure on a surface, 1 ft. wide, of which the top is 3 ft. below the surface?

$62.5 \times 3.5 \times 1 =$ Total pressure $= 218.75$ lb.

100. What is the unit pressure per square inch on the side of a vessel 10 ft. below surface of water?

Unit pressure $= .434 \times 10 = 4.34$ lb. per sq. in.

101. The water behind a dam is 25 ft. deep; determine what the total pressure will be per foot of length of the dam, and what the moment tending to overturn it.

Pressure per foot of length $= \frac{1}{2} wh^2 = \frac{1}{2} \times 62.5 \times 25^2 =$ 19 531.25 lb.

Moment $= \frac{1}{2}\, wh \times \frac{1}{3}\, h = \frac{1}{6}\, wh^3 = \frac{1}{2} \times 62.5 \times 25^2 \times (\frac{1}{3} \times 25)$
$= \frac{1}{6} \times 62.5 \times 25^3 = 16\,2760.42$ ft-lb.

102. Given two reservoirs 500 ft. and 2 000 ft. square and filled with water 20 ft. deep, the banks being 25 ft. high. How much heavier and thicker should the wall or bank be in the one case than in the other, and why?

There should theoretically not be any difference in heaviness or thickness, since the thickness is dependent upon the depth of the water alone and not upon the area of the reservoir.

103. Suppose a pile near the outer end of a pier to have an average diameter of 15 ins., and the depth of water to be 35 ft. What would be the total pressure against its surface resulting from a tidal current with an average velocity of 4 miles per hour?

A velocity of 4 miles per hour is equivalent to

$$\frac{5\,280 \times 4}{3\,600} = 5.87 \text{ ft. per sec.}$$

The static head, equivalent to this velocity,

$$= \frac{v^2}{2\,g} = \frac{5.87^2}{64.4} = .54 \text{ ft.}$$

The equivalent pressure per sq. foot $= 62.5 \times .54 = 33.75$ lb.

The area of the surface of the pile subjected to pressure $= 35 \times 1\frac{1}{4} = 43.75$ square feet.

The total pressure is therefore $43.75 \times 33.75 = 1\,476 \pm$ lb.

104. (*a*) Give the different methods of measuring the velocity of flow in a stream.

(*b*) Where is the maximum velocity in cross-section of stream?

(*a*) 1. By the use of surface or submerged floats, which are immersed in the stream, the time elapsed while traveling a known distance is recorded and the velocity per unit of time computed.

2. By noting the height to which water will rise in a pitometer tube immersed in the stream, thus giving the velocity head. The velocity may then be computed from the recorded head ($v = \sqrt{2gh}$).

3. By the use of a current meter. The velocity is given directly on a graduated dial.

(*b*) The maximum velocity is in the deepest portion of the stream, about $\frac{1}{3}$ below the surface.

105. Explain in detail the most accurate way of gauging the velocity of a stream.

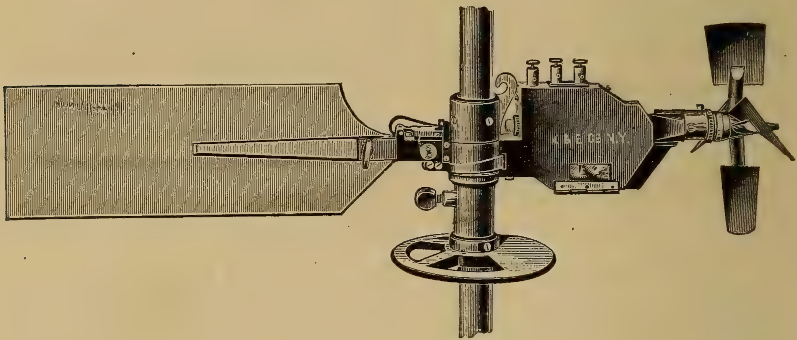
The velocity of a stream is most accurately gauged by means of a current meter.

Before any work is done the rating of the meter should be accurately known or determined. (This may be done by suspending the meter from a boat in quiet water and noting the index record as the boat is propelled at a known velocity.)

Divide the stream into convenient areas by vertical and horizontal planes.

Suspend the meter from an anchored boat or suitable rigging so that the vane will be immersed successively in each of the areas, thus determining the velocity in each.

The mean velocity can then be found by averaging the recorded velocities in each section.



106. How would you measure the discharge of a small stream (*a*) on which a tight dam is situated; (*b*) without a dam?

(*a*) If the water overflows the dam, determine the elevation of the crest and the head on same. This can be done by measuring with a hook gauge the elevation of the water surface about 10 feet back from the crest.

The condition of the ends of the dam should be observed.

The discharge may then be calculated by the weir formula,

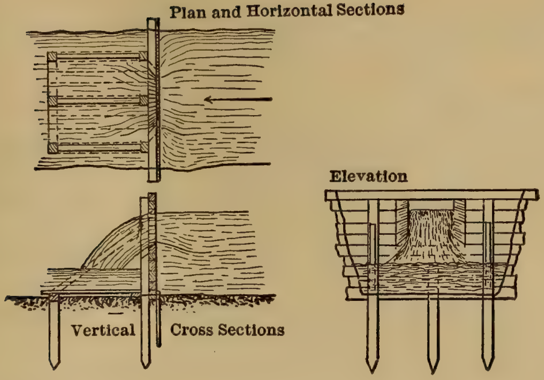
$$Q = 3.33\, b\, h^{\frac{3}{2}},$$

or other appropriate form, depending upon conditions.

If the velocity of approach is considerable it should be taken into account by increasing the value of h, by an amount

$$h_a = \frac{v_a^2}{2g} \quad (v_a = \text{velocity of approach, } h_a = \text{corresponding head}).$$

A special weir crest may be constructed on the dam by means of flashboards if very careful gauging is desired.

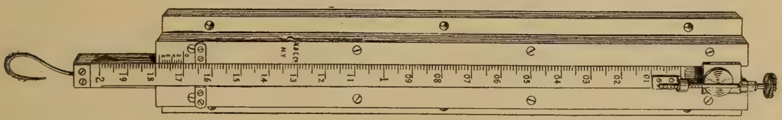


(*b*) Where there is no dam, a special weir may be constructed over the stream and the discharge obtained; or, the velocity gauged, the cross-section measured and the discharge computed by the formula $Q = A\ v$, or the Chezy-Kutter formula (see Q. 93), may be used, giving appropriate values to the constants s, n, and r as determined by measurements and observations.

107. What is a hook gauge and how should it be located in making weir measurements?

A hook gauge is a device for measuring the head of water on the crest of a weir. It consists of a graduated rod provided with a hook at the bottom; the rod is made to slide vertically in fixed supports, the amount of motion being read on a vernier.

It is operated as follows: The hook is brought to the level of the crest and the vernier read; it is then raised to the water level and the vernier read again; the difference in the readings gives the head. The hook should be inclosed in a box open at the bottom so that the water surrounding it will be calm, and the box located far enough back not to be affected by the curve at the crest (at least 6 ft.).



108. In the construction of a weir for measuring the flow of water from any source, state clearly all the requirements in form and arrangement that are necessary for the most accurate results.

1. The back of the weir should be vertical.
2. The back of the weir should be at right angles to the direction of flow.
3. There should be no end contraction or the end contraction should be complete.
4. The sheet should be prevented from expanding laterally by extending the upper portions of the sides a little down stream.
5. The crest should be in thin plate, the water touching only along one line.
6. The length of the crest should be at least three times the head on it.
7. The back should be vertical for a depth at least twice that of the head to reduce the velocity of approach.
8. The weir should be firm to prevent vibration.

109. In formulas for the flow of water in open chanels, how is the fall of the surface taken into account?

By introducing a quantity s representing the sine of the angle of slope of the surface with the horizontal or the fall in the surface divided by the corresponding distance.

110. In the application of Kutter's formula for computing flow, what value of n is usually taken?

For smooth brickwork	$n = 0.013$ to 0.015.
For clean iron pipes	$n = 0.013$ to 0.015.
For rubble masonry	$n = 0.017$ to 0.020.
For concrete conduits	$n = 0.012$ to 0.020.
For smooth earthen banks	$n = 0.020$ to 0.035.

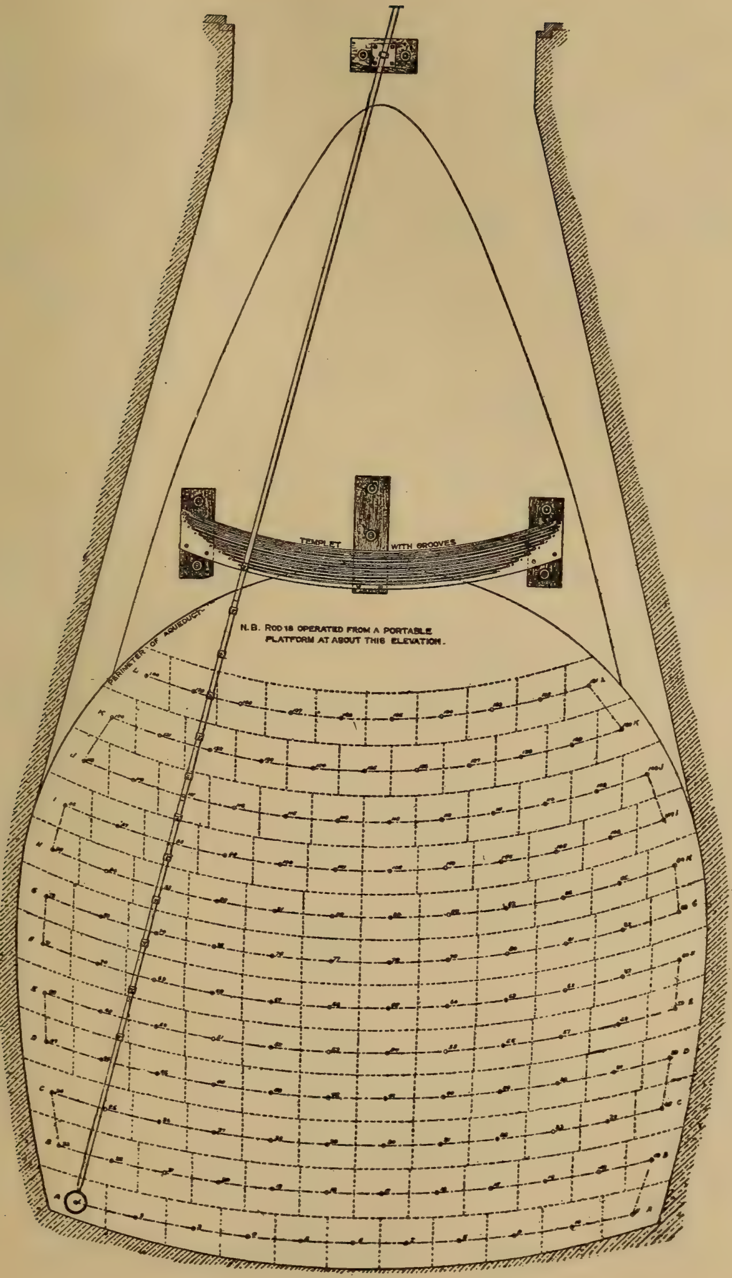
111. What is meant by the "mean hydraulic radius"?

It is a quantity expressing the ratio of the area of any water cross-section in a pipe or channel to the length of the wetted perimeter in same.

112. Describe how the flow in the Aqueduct is gauged.

A manhole is provided about 1 000 ft. south of Yonkers and fitted with special apparatus and working platform. A current meter attached to a $1\frac{1}{16}$-in. brass rod connected in 5-ft. sections is used for obtaining the velocity. By means of the rod and the adjustments provided, the meter can be placed in any desired section of the stream.

The area of the channel is divided into about 150 sections and the velocity obtained in each; the depth of water is also recorded.


TEMPLET WITH GROOVES
N. B. ROD IS OPERATED FROM A PORTABLE PLATFORM AT ABOUT THIS ELEVATION.
PERIMETER OF AQUEDUCT

The average velocity is then computed and the discharge = area $\times$ velocity.

Weirs are also constructed at several of the gate houses and the heads on the crest recorded daily. Tables have been prepared, giving directly discharges for any head, so that the discharge at any time may be readily obtained.

Where the weirs are so placed as not to be interfered with by the eddies and other disturbances, the results agree fairly well with those obtained by the current meter.

113. The average section of a stream for a distance of 100 ft is as follows, the fall of the stream is in the same distance 0.12 ft.:

Section.

Centre........	Depth =	25 feet.
5′ Right	"	8.5 "
15′ "	"	6.0 "
25′ "	"	0.0 "
5′ Left........	"	8.05 "
15′ "	"	6.0 "
25′ "	"	0.0 "

Take (c)—88 in the formula $v = c\sqrt{R\,S}$ and determine the value of V.

In the formula $v = c\sqrt{r\,s}$

$$c = 88$$

$$r = \text{hydraulic mean radius} = \frac{\text{area cross-section}}{\text{wetted perimeter}}$$

Area cross-section,

$$\frac{6 \times 10}{2} = 30$$

$$\frac{6 + 8.5}{2} \times 10 = 72.50$$

$$\frac{8.5 + 10}{2} \times 5 = 46.25$$

$$148.75$$

$$2$$

$$= \overline{297.50 \text{ sq. ft.}}$$

Wetted perimeter,

$$\sqrt{10^2 + 6^2} = 11.67$$

$$\sqrt{10^2 + 2.5^2} = 10.31$$

$$\sqrt{5^2 + 1.5^2} = 5.22$$

$$27.20$$

$$2$$

$$= \overline{54.40 \text{ ft.}}$$

$$r = \frac{297.50}{54.40}$$

$$s = 0.12 \div 100 = .0012$$

$$v = 88\sqrt{\frac{297.50}{54.4} \times .0012} = 7.13 \text{ ft. per sec.}$$

114. How many cubic feet of water per second will be discharged by a canal 125 ft. wide at top, 75 ft. wide at bottom, 10 ft. deep and 2 640 ft. long, with a fall of 40 ft.? (Take $c = 88$.)

$Q = A\,c\,\sqrt{r\,s}$
$Q =$ discharge in cu. ft. per sec.
$c = 88.$

$r =$ hydraulic mean radius $= \dfrac{\text{area section}}{\text{wetted perimeter}}$.

$s =$ sine of slope of water surface $= \dfrac{40}{2\ 640} = \dfrac{1}{66}$.

$A =$ area section $= \dfrac{125 + 75}{2} \times 10 = 1\ 000$ sq. ft.

Wetted perimeter $= 75 + 2 \times \sqrt{25^2 + 10^2} = 1\ 29 \pm$ feet.

$r = \dfrac{1\ 000}{129}$ feet.

$$Q = 1\ 000 \times 88\sqrt{\frac{1\ 000}{129} \times \frac{1}{66}} = 30\ 500 \pm \text{ cu. ft. per sec.}$$

115. Describe the method of ascertaining the horse power of a running stream. How much of the theoretical horse power can be delivered to a line shaft in a mill?

The discharge of the stream per second should be first ascertained and its weight, W, computed. The velocity should be measured and converted into velocity head, $\left(H = \dfrac{v^2}{2\,g}\right)$.

The horse-power $= \dfrac{W\,H}{550}$.

If the stream discharges over a weir, W will be the weight per second falling over the crest and H the available fall or head, and

$W = 62.5 \times 3.33\,b\,h^{\frac{3}{2}}$ $b =$ length of crest
$h =$ head on crest

and $H\text{-}P = \dfrac{62.5 \times 3.33}{550}\,b\,h^{\frac{3}{2}}\,H.$

Under the most favorable conditions not more than 90% of the theoretical horse power can be realized.

116. Suppose the quantity of water available for running a water wheel is 120 cu. ft. a second, the head 12 ft. and efficiency of the wheel 80%, how much work will the wheel do and how many horse power will this be?

The work done $= 120 \times 62.5 \times 12 \times .80 = 72\,000$ ft-lb. per sec. $= \frac{72000}{550} = 131 \pm$ horse power.

117. Find the horse power of a stream discharging 100 cu. ft. per sec., fall 10 ft.

$$H\text{-}P = \frac{100 \times 62.5 \times 10}{550} = 113.65.$$

118. Explain how to ascertain the time required to empty a reservoir.

Divide the reservoir into horizontal zones (by means of the contours, if possible), determine the volume of water in each zone (V) and the average head of each zone on the outlet (h).

The quantity of water discharged per second will equal the area of the outlet $\times \sqrt{2\,gh} \times$ a coefficient varying from 0.6 to 0.9, depending upon the form of the outlet.

By inserting the average value of h for the respective zones, the amount (Q) discharged per second by each is computed.

Compute the number of seconds required to empty any zone.

$$= t = \frac{\text{Quantity of water in any zone}}{\text{Rate of discharge for the zone at the outlet}} = \frac{V}{Q}$$

Then the total time ($= \Sigma\, t$) is found by summing up the number of seconds required to empty all the zones.

The narrower the zones are taken the closer will the computed result equal the correct time.

If the zones are equal in area the calculations are simplified, as $\frac{A\,d}{a\sqrt{2\,g}}$ is then constant, giving for any zone $t = \frac{Ad}{a\sqrt{2\,g\,h}} = \frac{c}{\sqrt{h}}$

and the total time, $\Sigma_t = \Sigma \frac{c}{\sqrt{h}}$ d being the contour interval,

A the area of the zone,

a " " " " outlet,

and $c = \frac{A\,d}{a\sqrt{2\,g}}$.

119. Describe how the flow of water in circulating pipes is affected by friction, stating the various cases and assigning values for each and quoting your authority.

The velocity of flow of water in pipes is *reduced* by friction along the interior surface. The amount of this friction increases as the roughness of the surface increases, as the velocity increases, as the length increases, but the friction decreases as the diameter of the pipe is increased. The friction is usually considered as causing a loss of head, resulting in a corresponding decrease in the velocity and discharge.

$$\text{Loss of head due to friction} = \left(\frac{f\,l}{d}\right)\frac{v^2}{2\,g}.$$

$f =$ coefficient of friction $=$ about .02.
$l =$ length of pipe in feet.
$d =$ diameter in feet.
$v =$ velocity in feet per sec.

When the pipe is less than 4 000 diameters there is an appreciable loss of head at entrance, which is equal to about $\frac{1}{1.5}\frac{v^2}{2\,g}$.

When there are sharp curves in the pipes the friction increases; the smaller the radius of the curve the greater the loss.

At changes in diameters or obstructions, there are still further friction losses.

120. Explain what is meant by hydraulic gradient? What provision should be made to insure successful work? NOTE: The latter part of this question refers to the case when the grade of the pipe is above the hydraulic gradient.

For definition of hydraulic gradient see question No. 96. No part of the pipe line should rise above the hydraulic gradient, if possible.

If air collects at the summit and cannot escape, the head due to the fall below this point is lost and the summit becomes the point of discharge. Where summits are unavoidable, "blow-offs" are provided to remove the air.

121. Contraction of fluid vein. Where does it have to be considered in designing a pipe line?

The contraction of the fluid vein will be appreciable when the length of the pipe is less than about 4 000 times its diameter, and should be considered in designing the entrance. The entrance should be built of a special casting having a bell-shaped mouth to reduce the loss of head to a minimum.

122. State all the sources of loss of head in passing water through pipes and the means by which they can be lessened by care in design and construction.

1. Loss of head at entrance.
2. Loss of head due to friction in the interior.
3. Loss of head due to bends or curves.
4. Loss of head due to changes in diameter.
5. Loss of head due to obstructions, connections and fittings.

The entrance loss may be lessened by arranging a bell-shaped entrance to the pipe; friction can be reduced by having the pipe of smooth bore throughout, by having it of as large diameter and as small length as possible. Curves should be avoided and when necessary be of as large radius as possible. The pipe should be kept clean inside, connections should have smooth faces, free from corners and projections; sudden changes in diameter should be avoided, reducers being employed for the purpose.

123. In the flow of water through channels and conduits, (*a*) state the several causes of resistance to flow.

(*b*) What is the principle cause of resistance to flow in long pipes?

a. Frictions along the sides and bottom, bends, sudden change of cross-section, obstructions, wind;

b. Friction along the interior of the pipe.

124. How would you go to work to measure the quantity of water flowing in a pipe?

Provide a graduated tank whose capacity is accurately known. To obtain the discharge, note carefully the time required to fill it, and compute the rate of flow; or, obtain the velocity by means of a Venturi meter, then knowing the cross-section of the pipe compute the flow, the frictional losses being allowed for by introduction of coefficient; or, use the formula (see Q. 93) after determining the diameter and length of pipe and the head on the outlet; or, weigh the water delivered by the pipe in a known time, and compute the volume of discharge from the weight.

125. What will be the *theoretical* volume of discharge per second from a reservoir through a pipe one foot in diameter discharging at a depth of one hundred feet below the surface of the water?

$Q = A\sqrt{2gh}$. $A=$ area of cross section of pipe, $h=$ the head in feet. $g=$ gravity constant, $Q=$ discharge in cu. ft. per sec.

$$Q = .78\,54 \times \sqrt{2 \times 32.16 \times 100} = 62.99 \text{ cu. ft. per sec.}$$

126. How many gallons of water will be discharged through a pipe 1 ft. in diameter, 328 ft. long, head $13\frac{1}{2}$ ft. coefficient of flow = .007?

$$Q = A\,v = .7854 \times D^2 \times \sqrt{\frac{2\,g\,h}{1\frac{1}{2} + \frac{f\,l}{D}}} = .7854 \times \sqrt{\frac{64.32 \times 13.5}{1\frac{1}{2} + .007 \times 328}}$$

$$= .7854 \times \sqrt{\frac{868.32}{3.444}}$$

$$= .7854 \times 16 \pm$$

$$= 12.5 + \text{ cu. ft. per sec.}$$

$$= 5625 \text{ gall. per minute.}$$

127. How many gallons of water will be discharged through a pipe 1 ft. in diameter, 328 ft. long, head 1 ft., coefficient of flow 0.02?

$$Q = \text{Area} \times \sqrt{\frac{2\,g\,h}{1.5 + \frac{f\,l}{d}}}$$

$$= .7854 \times 8.02 \times \sqrt{\frac{1}{1.5 + \frac{.02 \times 328}{1.0}}}$$

$$= .7854 \times 8.02 \times \frac{1}{\sqrt{8.06}} = 2.25 \text{ cu. ft. per sec.}$$

128. State all the sources of strain which metal in a rising main must resist?

1. Pressure due to head of water. 2. Water hammer caused by sudden stoppage. 3. Violent shocks caused by agitation of contained air due to sudden admission of water.

129. State clearly all the prominent causes of failure in water pipes in use?

1. Freezing of water in pipe. 2. Settlement, causing opening of joints and leakage. 3. Water hammer. 4. Excessive pressure. 5. Corrosion. 6. Electrolysis. 7. Defective material. 8. Air pressure when pipe is under vacuum.

130. In a system of distribution of water through pipes are air valves always necessary and where should they be placed?

The air valves are only necessary in long lines where there are summits at which the air is likely to collect. In cities fire hydrants usually take the place of air valves.

131. At a dead end or considerable change of direction of a pipe is any precaution necessary, and if so what?

A blow-off should be provided and the grades should be steep at dead ends. The pipe must be reinforced against water ram. At sharp curves special castings should be used. The two lines forming the turn should be secured together against water ram.

132. When water is pumped from a series of wells what are the chief causes of difficulty in pumping?

The main difficulty is the fluctuation of the water level in the wells, making it necessary to provide means for raising the water in the various wells separately. Forcing air into the wells is a method frequently employed. Clogging of inlets is another difficulty.

133. Describe in detail the method of laying a 30-in. water main.

The trench should be dug 4½ ft. wide, and at joints deep enough to permit access for caulking. Two blocks and four wedges are then laid on line a little below grade of pipes. The pipes are rolled over the trench, raised by a derrick and lowered into position, bells facing up hill. They are then raised to true grade by means of the wedges; the spigots should be entered well into the bell and be concentric with same. The gasket of oakum is driven into the annular opening, leaving about 3 in. for the lead. The lead is run in one operation so as to leave a projection bead which is driven in by caulking, making perfectly tight joints.

134. What is meant by the term duty as applied to pumping engines?

The "Duty" of a pumping engine is the number of foot-pounds of work done by the pump per million gallon heat units supplied by the boiler.

135. State the maximum, minimum and average rainfall in the Croton Valley. State about the minimum depth of rain that can be stored in the dryest year.

Maximum	64 in.
Minimum	35 "
Average	46 "

The available storage in driest year is about 12 inches.

136. Explain the theory of rain and that of the amount of rainfall as affected by winds and mountain ranges.

Rain results when atmospheric vapor-bearing strata are cooled to a sufficient extent to permit condensation, or where the pressure of the atmosphere is too low to keep the vapor in suspension.

The heat of the sun produces evaporation from all water surfaces and also from the surfaces of snow and ice. The vapor forms into clouds and remains in suspension until, through radiation, convection or other causes its temperature is reduced to the point of condensation. Winds and mountain ranges may cause increased or decreased rainfall, depending on conditions.

A warm south wind progressing to the north is favorable to rain. Ocean winds which carry a great deal of moisture produce rain when they blow into colder climates. Winds from southwest to southeast are more apt to be followed by rain in most parts of the United States. Winds progressing from a dry region are not apt to cause rain.

When a vapor-bearing strata of air is interfered with by a mountain range, rain is apt to occur on the windward side owing to the cooling of the air. The rain is largely cut off from the leeward side of the mountain, the progress of the rain-bearing winds being stopped. Rainfall increases with height, as the upper regions of the air are cooler and therefore not able to hold as much vapor in suspension.

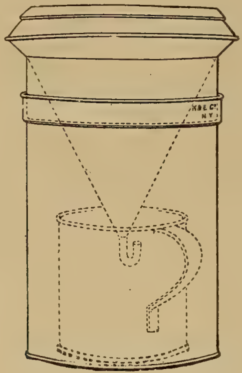
137. (*a*) How is the total rainfall for any area determined? (*b*) How the available rainfall? (*c*) State the full information for both necessary for purposes of securing water supply?

(*a*) The total rainfall is determined by a study of the rainfall statistics of the area in question, for as long a period as can be obtained.

The average, maximum and minimum rate should be worked out and also the frequency and duration of "low cycle" years (*i. e.*, years of extreme low rainfall).

The area of the watershed multiplied by the inches of rainfall in a given time gives the number of cubic feet of water which has fallen in that time.

(*b*) The available rainfall is determined by studies of the character, shape, slope and general topography of the watershed, amount of water surface, frequency and duration of low cycle years, etc.



A certain percentage of the total rainfall (usually about 30 to 50), depending upon these studies, is taken as available for the supply.

(*c*) For full information the following data should be obtained: The average maximum and minimum rainfall—their frequency and duration. A complete topographical map of the watershed—showing all timber land, extent of water surface, land under cultivation, etc., and giving contours.

The height of water and discharge of the streams in the watershed at different stages, especially during heavy freshets, determined by gaugings and studies of the streams.

138. State what you know regarding evaporation from water surface, from snow and ice and from earth.

Evaporation from the surface of water is caused by the excessive dissociation of molecules from the surface of the water over the condensation of the atmospheric vapor that is going on at the same time.

The amount of evaporation increases with the temperature of the water, temperature and dryness of the air, with the velocity of the winds or of the water, and increases as the depth of water decreases. This evaporation from exposed reservoir surfaces may reach 3 to 4 ft. per annum.

The evaporation is greatest during the day and least at night.

The evaporation must be taken into account in computing amount of storage required at a given reservoir site.

Ice and snow absorb sufficient heat from the surrounding atmosphere to liquify and vaporize some of the surface particles. The vapor can usually be seen rising from cakes of ice.

Evaporation from ice may amount to .06 in. per day and from snow .02 in. per day under favorable conditions.

139. State briefly the successive steps necessary to secure information regarding the availability of a watershed for purposes of water supply.

1. Make a general study of existing maps of the watershed and vicinity in order to arrange and subdivide the work of securing information.

2. Examine the water at various locations to determine its fitness for domestic use.

3. Organize a sufficient number of field and office survey parties and assign to each a definite part of the work.

4. Direct the respective parties to prepare a *complete* topographical map of the watershed, to study the rainfall statistics of the locality, to study the flow of all streams, to study the character of the water and the sanitary condition of the watershed, to investigate the possible damage to property, amount of territory to be acquired, industries affected, etc., to make borings at possible reservoir sites, studies of geologic formations, soil physics, evaporation, percolation, etc.

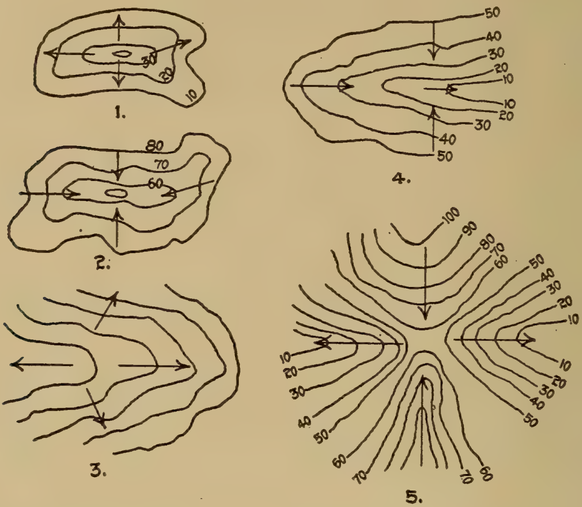
5. Make a comprehensive and thorough study of all the work accomplished and information secured to determine the availability of the watershed.

140. Explain how a drainage area is determined.

The first step is to secure or prepare if necessary a map showing contours in the watershed and the adjacent country.

On the map draw a continuous line dividing the watershed in question from adjacent drainage districts. This can readily be done by observing the direction of the contours carefully, and following the divides. The direction of flow is shown in the sketches below.

The area included within the line thus drawn is the area required and can readily be determined by the planimeter or other usual means of determining areas.



141. State all the important points which should be considered in the choice of a reservoir site for gravity water supply.

The points to be considered are:

1. The feasibility of constructing a reservoir at the site in question as determined by its geology and topography.
2. The relative elevation and location of the site with respect to the tributary streams and the locality to be supplied.
3. The storage capacity of the reservoir.
4. The character of the underlying materials, their permeability, percolation, evaporation, etc.
5. The extent and value of the property to be acquired and damage done to various interests affected.
6. The cost, quantity of work, and amount of time required to prepare the site for storage.
7. The sanitary condition of the adjacent territory.
8. The location of the reservoir with respect to filtration areas in case the water is to be filtered.
9. The proximity of suitable material for use in construction.
10. The cost of construction.

142. Given a watershed, having an area of 10 sq. m. with 5% water surface, calculate the storage necessary for daily supply of five million gallons and the dimensions of a spillway to provide for a flood of 80 cu. ft. per sec. per sq. mile.

Assume a mean annual rainfall of 40 ins., 40% of which is available for storage. The available yield of the shed is then $\frac{40}{12} \times .40 \times 10 \times 640 \times 43\,560$ cu. ft. per annum $= 371\,712\,000$ cu. ft. $= 2\,787\,840\,000$ gal. per annum.

The annual consumption is $5 \times 365 = 1\,825$ million gallons.

The loss by evaporation and percolation from the 5% or $\frac{1}{2}$ sq. mile of water surface is about equal to the annual rainfall upon its area, or $\frac{1}{2} \times \frac{40}{12} \times 640 \times 43\,560 \times 7.5 = 348\,580\,000$ gallons per annum.

Assume probable monthly percentages of the annual flow, loss and consumption and the resulting volumes as follows:

Months.	Available flow. 2 788 million gallons annually.	Loss by evaporation and percolation, 349 million gallons annually.	Consumption annually, 1 825 million gallons.	Surplus or deficiency, million gallons.	Storage required.
	Per cent. Million gals.	Per cent. Million gals.	Per cent. Million gals.		
January	10 = 279	4 = 14	8 = 146	+ 109	
February	10 = 279	5 = 17	8 = 146	+ 116	
March	12 = 334	6 = 21	6 = 110	+ 203	
April	10 = 279	7 = 24	7 = 128	+ 127	
May	8 = 223	9 = 31	8 = 146	+ 46	
Jnne	7 = 195	12 = 42	10 = 182	− 29	
July	6 = 167	15 = 53	11 = 201	− 87	298 million gallons.
August	5 = 140	15 = 53	12 = 219	− 132	
September	6 = 167	10 = 35	10 = 182	− 50	
October	8 = 223	8 = 28	8 = 146	+ 49	
November	9 = 251	5 = 17	6 = 110	+ 124	
December	9 = 251	4 = 14	6 = 110	+ 129	

300 000 000 gallons should be provided for.

To provide for a flood of 80 cu. ft. per sq. m. per sec. the total discharge will be $80 \times 10 = 800$ cu. ft. per sec.

Assuming that at flood the head on the crest will be 3 ft., we have

$$Q = 3.33\, b\, h^{\frac{3}{2}} \text{ or } 800 = 3.33\, b \times 3^{\frac{3}{2}},$$

from which length of spillway $= b = 46$ ft.

143. Describe clearly the method of accurately determining the character of foundation for an important dam.

The character of the foundation for a dam is determined by test pits and borings.

The valley across which the dam is to be built is "gridironed" or divided into squares of convenient size and a test boring made at each corner.

The borings should be carried down and into the rock underlying the valley.

Samples of the material penetrated should be brought up at every change in their character and generally at every 5 to 10 ft. in depth. These samples should be properly labeled and preserved.

Each boring should be numbered for identification and the character of the materials and the depths at which they are found properly recorded so that a correct plot of the boring may be made.

Vertical sections through the lines of borings should then be prepared from the recorded data showing the depths and character of all strata penetrated.

Lines are then drawn connecting the same strata in the adjacent borings, giving profiles of the strata.

A study of these profiles, the samples obtained, and the geologic features of the site gives the necessary information to determine the character of the foundation.

The methods of boring used for the purpose will vary with the character of material and depth of penetration.

Through the solid rock diamond drills must be used and the cores may be preserved intact.

Through hardpan and earth at considerable depth the water jet and pipe method should be used.

In shallow borings ordinary iron pipes or augers may be used or test pits dug.

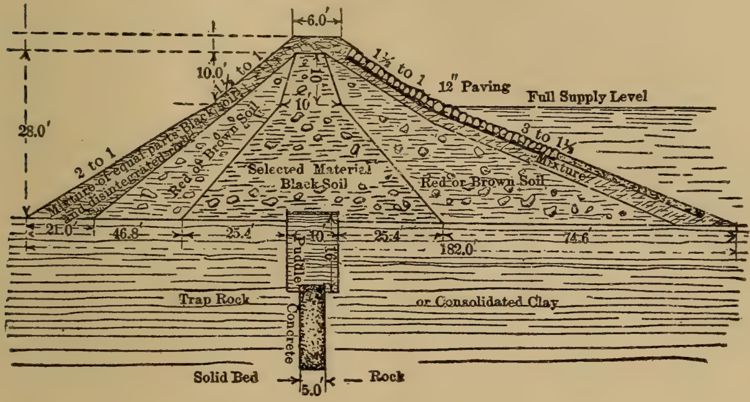
144. Write a report on your examination of a valley for the best location of a dam. Describe fully the examination made, the result of the examinations, and the reasons for the location you have made.

A report should contain first a description of the topographic features of the valley, describing the watersheds, their character and extent, the character of the water as to purity, etc., the geologic features, describing the different strata, giving their depths as determined by examinations with the aid of borings and test pits. It should contain all available statistics of the rainfall of that region and stream run-off. A rough estimate should be given of the property encroached upon, changes necessitated by the reservoir, and the population affected. Comparisons should be made for each tentative location between the available storage, the costs of the con-

struction, the land encroached upon, and the topographic features incident to each. In general the dam should be located at the narrowest part of the valley where the most substantial foundation can be had, and the greatest storage area secured.

145. Draw a section of an earthen dam to cross a valley, the depth to rock below the surface to the ground being 25 ft. at the deepest point, and the water surface to be 30 ft. above the ground at the same point. Give every detail to produce safe work and give reasons.

ASHTI DAM, INDIA.



The dimensions of the dam are shown in the sketch.

Foundation to be stripped and uncovered for at least 4 ft., drained, poor bottom replaced by firm material, and springs and seams plugged before depositing the embankment materials.

Materials.—Core of puddle or masonry carried down to rock to make the dam water-tight.

The puddle should be:

Coarse gravel,	1	part, to form a water-tight mixture.
Fine gravel,	3.5	"
Sand,	1.5	"
Clay,	.2	"

Material on up-stream face to be built of the finer material, and on down-stream face of the coarser, to facilitate drainage of the bank.

The puddle wall should be well bonded into adjacent materials during the construction. The material should be thoroughly compacted during the work.

Up-stream fall should be paved, paving to end in a good toe wall to prevent wash of the bank.

Where the dam abuts into the hillside special care must be taken to make the work watertight and any pipes or conduits passing through the dam should be surrounded with cut of walls of puddle or masonry to prevent lines of seepage forming.

146. Describe what you would consider a perfect material for use in puddling. State also what you would do in case you would have a job of puddling to do and such material was not available?

The best puddle is made of coarse gravel 1 part, fine gravel 3.5, clay 2.0 and sand 0.15. The clay should be opaque and uncrystallized and form a plastic mass with water.

If this material is not obtainable gravelly loam may be used, the finest material being placed near the outside of the wall, or a mixture of equal parts of coarse gravel, sand and clay may be used.

147. Describe the best method of using puddle in order to obtain an impervious bank.

The gravel should be spread loosely in thin layers, and upon it the clay is spread, the lumps being broken; the sand is then deposited on the clay. The material is thoroughly mixed by passing a harrow over it; it is well moistened and then rolled with a heavy grooved roller to a compact mass. The finished puddle should not be exposed to the drying action of the air, but covered with a layer of dry clay and sand.

148. Suppose a dam is to be founded on rock, and on uncovering the rock it is found to be seamy with water coming up at points, what would you do? Suppose there is a spring with considerable head, what can be done?

a. Remove the disintegrated portion of the rock, and pack quick setting neat cement or a rich mortar in the seams previously enlarged for the purpose, or if necessary pump grout into the seam until the flow is stopped.

b. In the second case tap the spring and lead it away through an iron pipe to the down-stream side of the dam; or tap the spring with an iron pipe carrying same up vertically with the masonry to a height greater than the head of the spring. If possible, the spring should be drained by pumping, when grout should be forced in under pressure to seal it.

149. What can be done to prevent water from following along a pipe which passes through a reservoir wall?

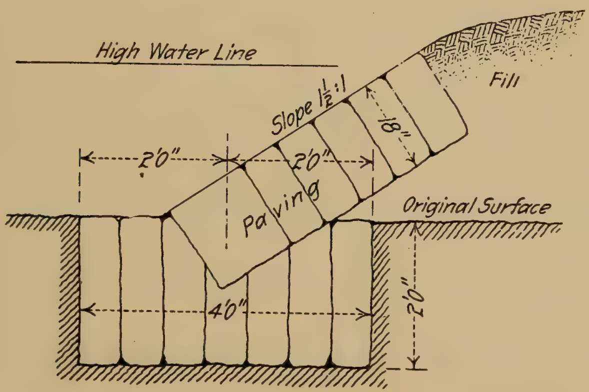
In the case of earthen walls non-porous material, such as puddle, should be thoroughly compacted around the pipe, or if possible the pipe should be enclosed in a masonry conduit. Special flange castings may be introduced at frequent intervals along the pipe. In the case of masonry walls the latter method may be adopted, or cut off walls of concrete or block masonry may be used at the joints. The pipes should be encased in neat cement and care taken that the joints of the masonry abutting the pipe be broken so as not to provide continuous lines for seepage.

150. When an earth bank for a reservoir or canal is to be founded on earth, does the surface need any preparation, and, if so, what and why?

Yes. The surface should be thoroughly cleared and grubbed and the surface soil stripped, for the vegetation and top soil unless removed will render the bank porous and yielding. Objectionable portions should be removed and replaced by solid material. Springs should be tapped or diverted to prevent undermining. The surface is then watered and compacted by rolling, and stepped so as to make a good bond with the embankment.

151. Make a sketch showing how the foot of a slope wall on the inside of an earthen reservoir bank should be supported and give your reasons for the construction shown?

The toe wall should form a secure support for the paving above it and effectually prevent sliding or settling of the latter. The sketch shows such a wall founded in the natural earth bottom having a high sustaining and abutting power, used on some of the embankments in the Croton Valley.



152. Describe the theoretical design of a heavy masonry dam.

1. Determine from the given conditions the height of the dam.
2. Assume a top width of 1/10 the height.
3. Assume a unit weight for the masonry to be used in the work.
4. Compute the depth at which the batter begins on the front face, that is, carry the dam section down with the top width to a point at which the resultant of the water pressure and the weight of the masonry just falls at the middle third of the width. The position of this point may be found thus:

Let W = weight of dam for height h: w = *wt* per cu. ft. of water; w^1 = *wt* per cu. ft. masonry; b = width of dam.

The moment due to the water pressure $= \frac{1}{6} wh^3$

The resisting moment due to the masonry taken about the point $\frac{1}{3}$ from the outside $= W \times \frac{1}{6} b$.

Then $\frac{1}{6} w h^3 = \frac{W b}{6}$; $h^3 = \frac{W b}{w} = \frac{h\, b\, w^1\, b}{w} = h\, b^2 \frac{w^1}{w}$; $h^2 = b^2 \frac{w^1}{w}$;

$h = b \sqrt{\frac{w^1}{w}}$ or about $1\frac{1}{2}\, b$.

5. From this point downward the back face may be vertical and the front face of the dam batters sufficiently *to keep the line of resultant pressure at the middle third.* Divide the dam into sections by horizontal lines or joints 10 ft. apart and obtain by moments or graphically the position of the line of pressure for reservoir full and empty at each joint. Compute also the maximum unit pressure on the masonry for reservoir full and empty at each joint. When the resultant falls at the middle third the maximum pressure equals twice the mean pressure.

6. Continue this procedure until a joint is reached at which the *unit pressure on the masonry begins to exceed assumed safe limits.* From this point down the *limiting pressure will control the width* of the dam. The width should be sufficient to reduce the unit pressures to proper limits, the lines of pressure then falling near the center of the dam.

Owing to the rapid increase in the weight the width will rapidly increase below this point, giving an extensive width at foundation bed.

The maximum unit pressure on the foundation bed should be computed to insure that it does not exceed the allowable unit pressure for the underlying material.

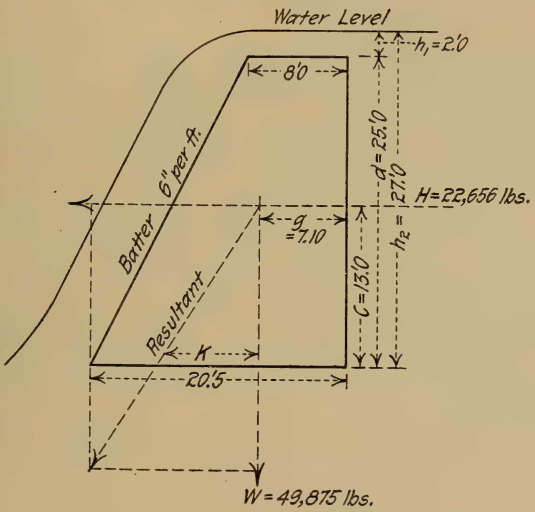
There are thus three stages of the calculation.

1. Width near top—Controlled by practical considerations (and made about $\frac{1}{10}$ height).

2. Width of middle portion—Computed so that line of pressure for reservoir full will fall just at the middle third.

3. Width of lower portion—Computed so that there will be no excessive unit pressure on the masonry.

153. Given an overflow masonry dam 8 ft. wide on top with vertical back, front batter 6 in. per ft., height 25 ft., weight of masonry 140 lbs. per cu. ft., flood 2 ft. over crest, show whether or not the dam will be stable.



Horizontal Pressure $H = d \times \frac{1}{2}(h_2 + h_1) \times 62.5 = 22\ 656\ 625$ lbs.
Distance to Center Pressure,

$$c = \frac{1}{3}\ \frac{h_2^3 - h_1^3}{h_2^2 - h_1^2} = 13.0 \text{ feet.}$$

Moment of water pressure $= H \times c = 294\ 531$ ft-lbs.

The weight of the dam $W = \dfrac{8 + 20.5}{2} \times 25 \times 140 = 498.15$ lbs.

By taking moments about the back, the distance of the center of gravity to the back of the dam $g =$

$$\left\{ 8 \times 25 \times 4 + \frac{12.5 \times 25}{2} \times \left(\frac{8 + 12.5}{3}\right) \right\} \div \left(\frac{8 + 20.5}{2}\right) \times 25$$

$= 7.1.$

When resultant falls at $\frac{1}{3}$ from face, $k = \frac{2}{3} \times 20.5 - 7.1 =$

The moment of resistance $= W \times k = 327\ 679$ ft-lbs.,

$$Wk = Hcf, \quad f = \text{factor of safety} = \frac{Wk}{Hc} = 1.1+$$

The dam is therefore stable against overturning.

To insure stability against sliding,

$$H < W \times 0.75 \qquad (0.75 = \text{coefficient of function}),$$

which is seen to be the case.

The maximum unit pressure on masonry $= 2 \times \frac{W}{20.5}$ is very small as is also the pressure on the foundation.

154. State the important details of construction of (*a*) a heavy masonry dam; (*b*) such features as are peculiar to concrete.

The important details are:

1. Temporary structures to divert the flow of the river should first be built so that the work of constructing the dam may be carried on in the dry. These structures should be of rigid and fairly permanent character and of sufficient capacity so that the work on the dam proper will not be endangered.

2. The excavation is then proceeded with, the material being disposed of to the best advantage. In making the excavation the slopes should be protected from slides and the bottom kept well drained. The foundation should be carried down to a satisfactory rock stratum, the soft and decomposed rock being removed.

3. All fissures, holes or seams in the bottom must be thoroughly closed by grouting and springs should be led away below the dam or securely plugged.

4. Before starting the masonry the rock surface should be flushed and painted with neat cement mortar and a rich concrete or mortar used to fill up the irregularities.

5. The masonry should be laid (using the precautions outlined in Q. No. 155) so that the entire structure will be a compact and homogeneous monolith.

6. Where the dam abuts into the hillsides special care should be taken to make the joints tight.

7. Where pipes or other structures are built through the dam, cut-off walls should be constructed and the work done in the tightest manner possible to prevent the creation of lines of seepage.

(*b*) For Concrete see Q. No. 40.

155. In the construction of a dam in stone masonry to resist the passage of water through it state minutely every precaution to be taken to make the dam itself watertight?

1. The sand, cement and stone should all be of the best quality; the mixing and using of the mortar carefully supervised.

2. The upper and lower faces of the dam should be built of ashlar laid in close joints.

3. The dam should be built on a well-prepared rock foundation, the rock being painted with neat cement before the masonry is laid.

4. The inside or backing may be of rubble or concrete.

5. The joints in the rubble must be thoroughly filled with mortar, large stones should be used, and as few spalls as possible; care must be taken that no open spaces are left under the stone.

6. The bonding should be thorough, horizontally and vertically and all unfinished portions should be racked so that on joining new work a good bond will be secured.

7. The face joints must be thoroughly pointed with 1 to 2 mortar.

8. In joining old and new work the old surface must be well cleaned and painted with cement grout before laying masonry.

9. No work should be done in freezing weather. The stones must be well wet before using. No mortar partly set must be used. In cold weather the sand and stones should be heated. In warm weather the masonry should be kept wet, as the loss of too much water interferes with setting and injures the masonry.

10. Where the dam abuts into the sides of the valley proper embankments must be built to prevent the passage of water around them.

11. Should the foundation be seamy or springs be encountered, they must be securely plugged by grouting or otherwise.

12. Pipes or conduits passing through the dam should be protected by special cut-off walls and neat cement to avoid forming lines of seepage.

156. In laying up the masonry in a dam what measures as to shape of stone, cutting same, bonding same, and laying same will tend to make the tighest work?

1. As to shape, the body of the dam should be composed of large blocks of rubble, as few spalls as possible being used; the faces of the dam above the river bed should be constructed of large blocks of cut stone, laid in 1:2 mortar.

2. As to cutting, the rubble blocks should be trimmed roughly to remove irregular projections and feather edges. The face stones should be dressed to a true even surface at the joints to a depth of a foot or more, the back being roughly squared. Special stones, such as required at inlets and chambers, etc., should be cut to exact dimensions.

3. As to bonding, the rubble composing the body of the wall should be thoroughly interlocked and unfinished work should be

"racked back"; face stones should be bonded into the rubble backing by the use of frequent headers.

4. The stones should be laid on natural bed in first class Portland cement mortar, all joints being entirely filled with mortar. The face joints should be inclined inward, so as to make bed joints if possible normal to face of dam. All face joints should be raked to a depth of about 2 in. and thoroughly pointed with a rich Portland cement mortar.

157. Describe minutely everything to be done in setting a large rubble block in the heart of such a dam, from the time the stone is lifted until the setting is complete. What objections, if any, are there to the use of grout in such a case? State fully and clearly.

a. After the stone is lifted give it a thorough drenching; meanwhile the mason should prepare the mortar bed for same; the stone is then raised and set on its natural bed in the place thus prepared. It is now raised again, the mortar bed inspected and sufficient mortar added to fill the joints. It is then finally set. Spalls should be placed only where necessary to give an even bed for the large block, as few as possible being used. No joints should be filled with mortar after the blocks are in place.

b. Grout is porous, has not sufficient binding qualities, and will not prevent the passage of water.

158. State what you know about the mechanical analysis of sand, gravel, etc.?

Sand with respect to size is called coarse when the grains range from 1/16th to 1/8th of an inch in diameter, fine from 1/16th to 1/24th, and very fine, from 1/30th to 1/60th. The fineness of sand is obtained by passing through a series of sieves ranging from 20 to 170 holes per lineal inch and noting the percentages retained. When the size is very small, the fineness is determined by "water elutrition," which consists of noting the time that it takes the particles of sand to sink in water, the finest taking the longest time. When the sand is to be used for filter beds, the *effective size* and the *uniformity coefficient* are determined; the former is that size than which 90% is coarser and 10% finer; the latter is the ratio between the effective size and that size than which 60% is coarser and 40% finer. The voids in the sand can easily be determined by putting it into a vessel of known capacity and noting the volume of water that may be added to overflowing. The cleanness can be determined by rubbing a little in the palm and observing the dust left after the sand is thrown away. Sharpness of sand is determined by examination with a lens, and noting the sound when rubbed near the

ear. The size of the gravel can be determined by using a series of sieves of varying meshes.

159. Discuss the important points to be considered in the construction of a large distributing reservoir as is proposed near Yonkers.

The important points to be considered are:

1. The suitability of the site with respect to *a.* Its elevation above sea level. (It should be high.) *b.* Its storage capacity. (Should be sufficient for a week's supply.)

2. Character of the material underlying the site. (Should be reasonably watertight.)

3. Its location with respect to the city and watersheds system. (Should be on a reasonably direct line from the watershed to the city.)

4. Cost of necessary land. (Must not be prohibitive.)

5. Cost of constructing the reservoir. (Must not be prohibitive.)

6. Disposal of the excavated material. (As much as possible should be used on the work and the rest used for filling.)

7. Imperviousness of the banks and bottom. (Both must be made watertight and durable.)

8. Provision for blow-off and cleaning. (Should be arranged in units and apparatus be provided for this purpose.)

9. Appliances for regulating and measuring head of water, rate and quantity of flow should be provided.

10. Connections to water supply system. (Gate houses should be provided to divert the water to all desired sections.)

11. General appearance when finished. Embankments should be sodded, walks built, railings, etc., to secure safety and an excellent appearance.

12. The Construction Details—Character of all materials must be the best, the work done in best manner for safety, durability and economy.

160. State what you know regarding sedimentation in reservoirs and its prevention.

Sedimentation in storage reservoirs is an object usually to be desired and not prevented. As a preliminary to filtration sedimentation is often resorted to and sometimes promoted by the admixture of chemicals.

Sedimentation relieves the water of a large part of the suspended impurities and therefore improves its quality.

In reservoirs exposed to the sun the character of the water is affected by organic growths, such as bacteria and algæ. These give to the water the somewhat fishy taste and odor. The addition of a small amount of copper sulphate has been found to prevent these growths to some extent.

In some cases it is desired to prevent sedimentation owing to clogging of valves, etc., and to keep the bottom of the reservoir clean. In such cases the arrangement of inlets and outlets to the reservoir should be such as to produce a continuous motion of the water, thereby preventing settling; or submerged pipes, into which air or water is forced under pressure, may be employed for the same purpose.

161. Describe fully a system of water filtration suitable for a large city.

The essential features of a large filtration plant are:

1. Conduits leading from the storage reservoirs to the filter plant of sufficient capacity to carry the maximum flow.

2. Settling basins for the reception of the raw water, divided into sections for cleaning.

3. Gates, etc., controlling the flow into these basins.

4. A large number of filter beds divided into units of convenient size. Each filter bed may be about one acre in area and about twenty beds comprise the unit. Each bed about 4 ft. thick, constructed of sand and gravel, ranging in size from coarse to very fine, the finest being on top.

5. Necessary pipes, etc., to regulate the flow of water to the various filter beds. The arrangement should be such that any filter bed, any unit or any system may be operated independently of all the others.

6. Apparatus for measuring and regulating the depth of water on the filters.

7. The necessary filtering materials, consisting of layers of broken stone and sand, decreasing in size from very coarse to very fine, the total thickness of the bed being about 4 ft.

8. Under drains for the collection of the filtered water.

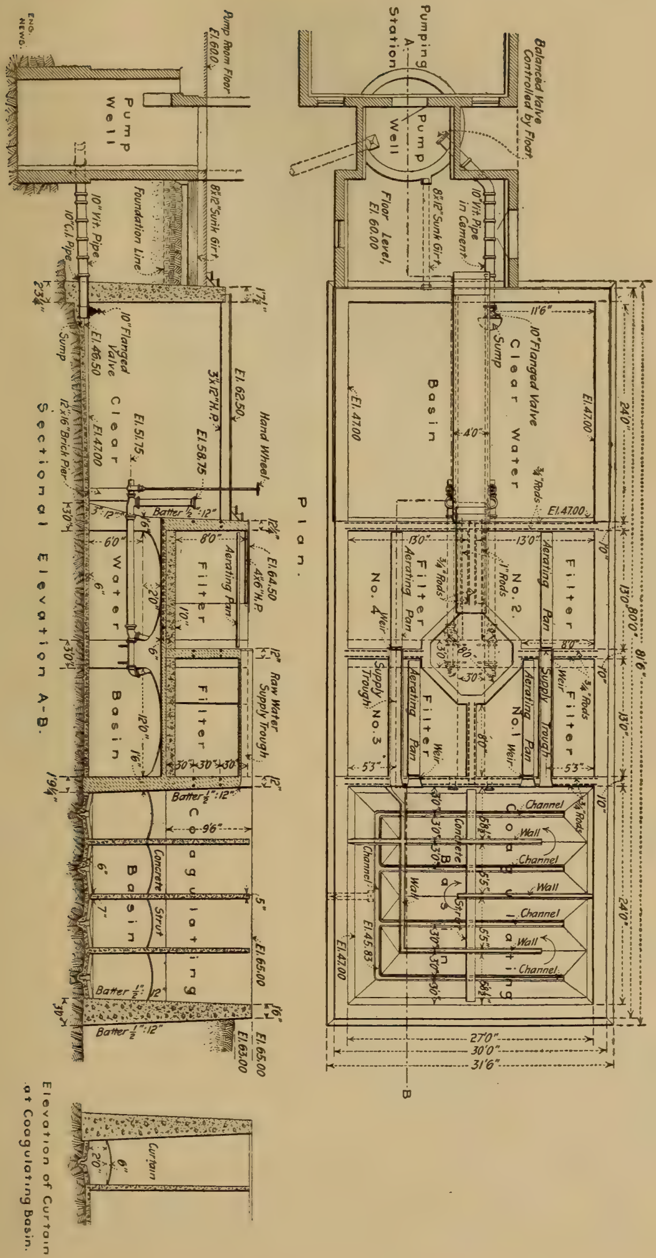
9. Receiving basins for the filtered water.

10. Apparatus regulating the flow into the latter.

11. Appliances for screening and washing the sand.

12. A laboratory for examining the condition of the water before and after filtration.

The sketch below shows a modern filtration plant for a city.


Plan.
Balanced Valve Controlled by Float
Pumping Station
A
Pump Well
10" Vit. Pipe in Cement
8"x12" Sunk Girt.
Floor Level, El. 60.00
10" Flanged Valve
Sump
Clear Water Basin
El. 47.00
3/4" Rods
Filter No. 2.
Aerating Pan
Filter No. 4
Filter No. 1
Filter No. 3
Supply Trough
Weir
1" Rods
Coagulating Basin
Channel
Wall
Concrete Strut
El. 45.83
B
27'0"
30'0"
31'6"
24'0"
13'0"
80'0"
81'6"
Sectional Elevation A-B.
Pump Room Floor El. 60.00
8"x12" Sunk Girt.
Foundation Line
10" Vit. Pipe
10" C.I. Pipe
El. 46.50
10" Flanged Valve
Clear Water Basin
12"x16" Brick Pier
3"x12" H.P.
El. 62.50
El. 58.75
El. 51.75
Hand Wheel
Batter 1/2":12"
El. 64.50
4"x6" H.P.
Filter
Raw Water Supply Trough
Concrete Strut
El. 65.00
El. 63.00
ENG. NEWS.
Elevation of Curtain at Coagulating Basin.
Curtain

162. State the important points to be considered in the construction of an open canal for carrying water supply.

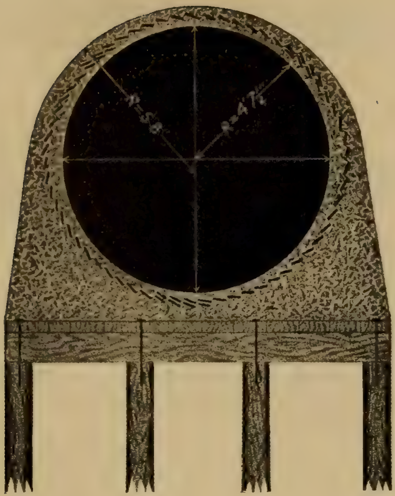
The following points must be considered:

1. The foundation and slopes should be stripped of all perishable material after the excavation has been completed, replaced by good firm earth and compacted.
2. The bottom and slopes of the canal should be made as water-tight as the means at hand will permit. (Paved, puddled, or concreted if possible.)
3. The section adapted should be sufficient to carry the maximum flow required without the water level rising above the banks or protected portion of the slopes.
4. The grade should be such that the velocity will not exceed 6 ft. per second, so that there will be no injury to the canal lining.
5. The bottom and sides should also be made as smooth as possible to give a maximum discharge with a minimum section.
6. Where a change of direction of grade or of cross-section occurs, the change should be made gradually to prevent loss of head, and excessive velocity and consequent liability to wash of the lining or deposition of sediment.
7. At the head works and other places proper screens should be located to prevent any undesirable substances from entering the canal.
8. Provision should be made for emptying the canal when required for the purpose of cleaning, repairs or renewals.
9. The plans and specifications should be followed and all the work done in as first-class a manner as the available funds permit.

163. Show by sketches and describe the method of carrying a large conduit over a marsh.

A conduit may be carried over marsh in several ways.

1. By piles. Three lines of piles, about 6 to 10 ft. centers longitudinally, are driven to firm bearing along the line of the conduit. Upon the piles properly cut off a timber platform or a concrete base is built for the support of the conduit. (Cut, p. 119.)
2. By mattresses. These are made up of bundles of fascines and deposited over an area extending some distances outside of the conduit lines; upon these mattresses the foundation course of concrete or timber may be built for the support of the conduit.
3. By sheeting. Heavy sheet piles are driven along the outside lines of the conduit and the material for several feet in depth excavated until a satisfactory depth is reached. The trench is then refilled with concrete forming the foundation course for the conduit.



164. Explain the method of designing a masonry arch viaduct to carry an aqueduct.

1. The section of the aqueduct being known, the depth of the structure above the arch, and the span and rise of the latter may be tentatively arrived at by studies of the surveys, condition of the stream, height and extent of opening required and other determining factors.

2. The thickness of the arch ring and grade of invert is then determined, which fixes the spandrels, roadway, and other parts of viaduct. The load considered on the arch should include its own weight, the dead weight of the structure above it the weight of the water in the conduit and the moving live load on the bridge. A tentative value of the thickness may be obtained by Trautwine's formula,

$t = \dfrac{\sqrt{r + \frac{1}{2} s}}{4} + 0.2$ and the graphical method applied to test its suitability.

3. The thickness being determined, the width of the abutment at the springing and the width at the foundation line are determined to satisfy the theoretical and practical requirements for stability.

4. Where two adjacent arch spans bear on one abutment the thrust of both should be combined to obtain the direction and intensity of the resultant.

5. The thickness of the material forming the conduit should be sufficient to withstand the water pressure.

6. The abutments should be carried down to a satisfactory rock foundation, the width being increased over the theoretical conditions required.

165. Explain the method of designing a steel water tower 100 ft. high, 40 ft. in diameter.

In designing a water tower the thickness of the plates must be sufficient to safely withstand the strain due to:

1. Static pressure of the water.
2. Wind pressure.
3. If the tank is mounted on pillars the anchorages must be strong enough to withstand the overturning moment of the wind.
4. In splicing sections of the rings, the rivets must be sufficient to transmit the strain.

Thickness of metal required at any depth h, to resist the static pressure of the water.

$$= T = \frac{p\,d}{2\,s}.$$

h = depth of water at point in question (in feet).
d = diameter in inches.
s = allowable strain in metal, lbs. per sq. inch.
p = pressure of water at depth $h = .434\,h$. lb. per sq. in.

Thickness required to resist the pressure of the wind when tank is empty.

$$= T = \frac{H\,w\,\frac{H}{2}}{\pi\,d\,m\,S}$$

T = thickness required in inches at any point.
H = height of standpipe above point in feet.
w = pressure of wind per foot in height.
d = diameter in feet.
m = sin. 45° = .707.
s = allowable tensile strain lb. per sq. in.

In tanks with large diameters the thickness will usually be determined by the hydrostatic pressure, but in high thin tanks the wind pressure will determine the thickness.

For convenience in design the height may be divided into horizontal sections 10 feet apart and the thickness required for each section calculated.

When the tank is mounted on pillars the total wind pressure on its surface multiplied by the distance from its center of pressure to the tops of pillars and also to the anchorage will give the overturning moment at these points; these connections must be designed to withstand the resulting strains.

166. A stone arch bridge must take the drainage of 5 000 acres. How many cubic feet per second must be carried?

$$c = 0.5;\ s = 12;\ y = 1.5.$$

$$Q = c\,y\,\sqrt[4]{s\,A^3}$$
$$= .50 \times 1.5 \times \sqrt[4]{12 \times 5000^3}$$
$$= .75 \times 1\,106+ = 829+ \text{ cu. ft. per sec.}$$

167. Assume bridge semicircular for 50-ft. roadway; design opening and show by sketches approximate construction.

The area of culvert opening may be found by Talbot's formula.

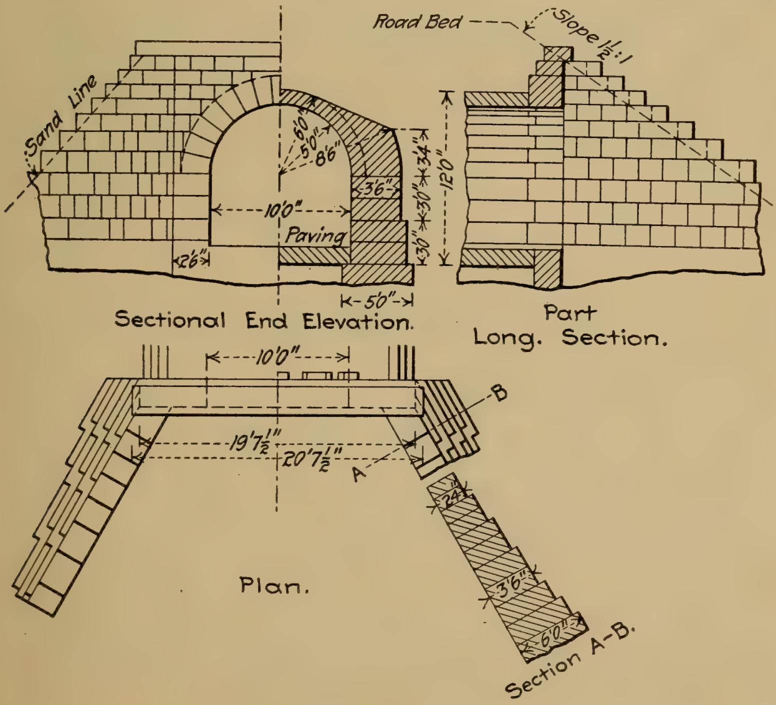
Area opening = Constant $\sqrt[4]{(\text{Drainage Area in acres})^3}$ in sq. feet.

Constant $= \frac{1}{6} \pm$ for rolling country,
$= \frac{1}{3} \pm$ " hilly "
$= 1 \pm$ " mountainous "

Using $c = \frac{1}{6}$

$$A = \tfrac{1}{6} \times \sqrt[4]{5\,000^3} = 99 \text{ sq. feet.}$$

A 10 ft. semicircular arch culvert having an area of 100 sq. ft., will answer the purpose.



The total discharge being 829 cu. ft. per sec., the velocity will be 829 ÷ 99, or 8.4 ft. per sec., and the grade fixed accordingly; or, a maximum velocity may be assumed and the area required found by dividing it into the flow. The grade can then be computed by the Chezy Kutter formula or taken out of tables.

168. A culvert must take drainage from 1 000 acres. How many cubic feet per second must be carried by the culvert? Use formula $Q = c\,y\,\sqrt[4]{s\,a^3}$, where Q equals cubic feet per second reaching culvert; c equals proportion of rainfall reaching culvert; y equals rainfall per hour; s equals average slope of watershed in feet (per 1 000 ft. of horizontal distance) and a equals acres of watershed. (Give values to c, y and s according to your judgment; exact quantities are not required).

Assume $c = .50$, $y = 1.00$, $s = 10.00$.

Then $Q = .50 \times 1.0 \times \sqrt[4]{10 \times 1\,000^3} = 158$ cu. ft. per sec.

169. Calculate the opening necessary in a road culvert having a fall of 3 in. in 30 ft., to carry the flood flow of a brook draining 1.25 sq. miles of farm country, with a general slope of 5 ft. in a thousand.

$$Q = c\,y\,\sqrt[4]{S\,A^3}$$

$$0.5 \times 1 \times \sqrt[4]{5 \times 800^3}$$

$$= 112.5 \text{ cu. ft. per sec.}$$

To calculate opening,

$$Q = A\,v = A\,c\sqrt{rs},$$

$$s = 3'' \div 30' = \tfrac{3}{360} = \tfrac{1}{120},$$

Assume $c = 40$.

" $r = 3\tfrac{1}{3}$.

$$Q = A \times 40 \times \sqrt{\frac{3\frac{1}{3}}{120}}.$$

$$112.5 = A \times \tfrac{40}{6}, \qquad A = 17 \pm \text{ feet.}$$

A 4 × 5 culvert should be used.

170. Suppose a tank of given height h, and diameter d, to be filled with water, how would you tell the tensile strain on the hoop which resists pressure on the lower foot of height?

Let p = pressure per square inch at center of hoop.
h = head of water on center of hoop.
w = weight per cu. ft. of water = 62.5 lbs.
r = radius of hoop in inches = $\frac{1}{2}$ d
t = thickness of hoop metal in inches.
s = strain on hoop in lbs. per square inch.

$$\text{Then } p = \frac{w}{144} \times (h - 0.5) = .434\ (h - 0.5).$$

$$p\ r = s\ t$$

$$\text{Therefore } s = p\frac{r}{t} = .434\ (h - 0.5)\frac{r}{t}.$$

DOCK DEPARTMENT.

171. Describe the operation of making a hydrographic survey for a pier on the North River, together with the location of property lines, etc.

1. Establish accurate traverse lines at or near the pier site and locate all property lines, streets, shore lines, obstructions, topographic and hydrographic features with reference to them, and show contours at 2-ft. intervals.

2. Take soundings in the vicinity of the proposed pier and prepare a contour map of the bottom. (See Q. No. 172.)

3. Take borings at the pier site sufficient in number and to sufficient depths so that the character of the underlying material will be fully established. (See Q. No. 174.)

4. Plot the work to a large scale. The maps will give all the information required to proceed with the design and construction of the pier.

172. Describe in full detail the method of sounding an area under water in a tideway so as to get accurate depths and locations.

Soundings are made with cylindrical shaped leads, weighing about twenty pounds. These are attached to lines made of Italian hemp, the size depending upon the attached weight. The lines are fully stretched before put into use, graduated and tagged every five feet; intermediate feet being marked by cotton strips. For depths less than fifteen feet sounding poles may be used. A boat is provided, brought into any desired position, the lead cast out and the depth recorded. The location of the point at which the sounding has been taken may be obtained—

1. By reading 2 or more angles from the shore to a flag held in the boat.

2. By angles read in the boat to objects fixed on the shore.

3. By keeping along known range lines.

4. By known time intervals, the velocity and direction of the boat being known.

During the progress of the work, readings of a tide gauge should be taken hourly, or an automatic gauge provided. All soundings should be reduced to the established datum plane before plotting the work, and a contour map of the bottom of the tideway should be prepared from the plotted depths.

173. To what plane of reference should surroundings in a harbor be referred and for what reasons?

Soundings in a barbor are usually referred to mean high water, as this is the most constant of the tidal conditions. The datum for the Dock Department in the City of New York is local mean *low* water.

174. Describe all the methods in use in dock building for determining the character of the earth strata down to rock at any point before beginning the building of a bulkhead.

The character of the strata may be determined by—

1. Sinking shafts or test pits.

2. By sounding or boring.

For depths from 10 to 20 ft., iron rods, pipes or augers 2 in. to 3 in. in diameter are used.

3. For greater depths, pipes may be sunk with the aid of water and samples of material brought up by buckets lowered into the pipe.

4. By the water jet: An iron pipe $1\frac{1}{2}$ in. in diameter is driven down, and into this a $\frac{3}{4}$-in. pipe is inserted. Water is forced into the *inner* pipe and issues through perforations in its lower end, loosening the material, which with the water rises between the pipes to the surface.

At intervals the bottom of the inner pipe is replaced by a special section by means of which a sample of the material is brought up.

This method is applicable to all material except rock and for all depths.

5. Borings in rock are made by the diamond drill.

This consists of a core bit, core lifter and core barrel. The core bit is provided with several diamonds, forming cutting edges. The bit is forced into the rock and the core forced into the barrel. The core can be brought to the surface at any time by means of the lifter.

Complete records should be kept of the location of the borings, character and depths of all materials penetrated, samples of same

and all other pertinent information obtained. Profiles along required lines are then prepared from the data and the character of the foundation fairly established.

175. Describe clearly and fully the process of cement testing in use in building under water.

The tests for cement are:

1. Test for fineness of grinding.
2. Test for specific gravity.
3. Test for time of setting.
4. Test for soundness.
5. Test for strength.

1. The test for fineness is made by passing the cement through sieves of various meshes and noting the percentages retained in each. Not more than 2% should be retained on a No. 100 seive, and 10% on a No. 50.

2. Specific gravity of cement is determined by using a special specific gravity balance. The specific gravity should be about 3.1.

3. Time of setting—activity.

Pats of cement are made with about 2.5% water, 2 or 3 in. diameter, and $\frac{1}{2}$ in. thick. They are immersed in water at 65° F., and the time required to set hard enough to bear $\frac{1}{12}$ in. wire having a $\frac{1}{4}$-lb. weight, and $\frac{1}{24}$ in. wire having a 1-lb weight, is noted, giving "initial set" and "final set." For a good cement the time for the initial set should be less than 45 minutes and the final set within 10 hours.

4. Soundness is determined by immersing the pats made with thin edges in water and noting blowing or cracks at edges, which indicates free lime or magnesia. If lime is present, storage will improve the cement. Magnesia is injurious. This test may be accelerated by immersing the pats in a steam bath.

5. Strength: Briquettes having a cross section of 1 sq. in. are made of neat cement and also of various mixtures of cement and sand. They are allowed to set one day in air and then are immersed in water. After periods of 24 hours, 7 days, 28 days, etc., they are broken by testing machines and the breaking weights noted.

A good Portland cement should develop a strength at the end of one day, of 175 lb. per sq. in.; at the end of 7 days, 450 lb. per sq. in.; at the end of 28 days, 550 lb. per sq. in.

176. Describe clearly and fully every part of the process of making one of the large concrete blocks in use in bulkheads with every precaution needed for the best work.

The concrete blocks are composed of 1 : 2 : 5 mixture, moulded in air and allowed to stand 10-14 days before shipping to work. The mould boxes are cored for chain holes. The grooves match in adjacent blocks and are later filled with concrete in bags. The back of the blocks is moulded so as to give a good bond with the backing.

177. Describe the best method of setting concrete blocks for a bulkhead under water, including location as to line and level.

The necessary preparation and leveling of the site is done by divers with the aid of heavy iron straight edges. The blocks are brought to the site and lifted by a crane. When swinging into position they are suspended about half their depth in the water to reduce the load on the lifting tackle. When near the right location they are lowered and accurately adjusted when about 3 or 4 inches above lower course. Accurate adjustment for line may be secured by timber guide pieces wedged into the dowel grooves in the blocks, and by stop timbers attached to the blocks already set. Divers assist in the work when necessary. After the blocks are set the dowel grooves are packed full of concrete.

178. When it is necessary to lay concrete under water, how can it be done with good results?

Concrete may be deposited under water

1. In paper or burlap bags carefully lowered and placed into position with the aid of divers.

2. A V-shaped box of wood or iron is commonly used. It is filled with concrete and lowered by a crane. One of the sloping sides is swung open by pulling out a pin, which is attached to a string reaching the surface, and the concrete deposited in place.

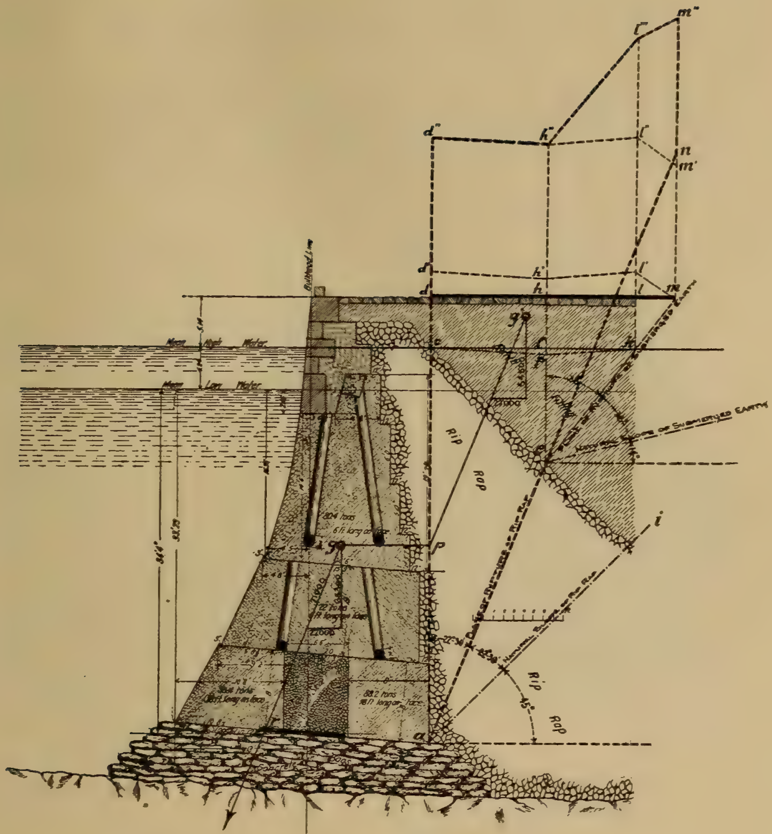
3. Long hopper shaped tubes called "Tramie" are also used. They are open at both ends and their length is adjustable. They are suspended in place by a crane, and a continuous flow of concrete kept up. The tube is thus kept full and separation of material is avoided.

In all methods no opportunity should be given for the material to separate. Leveling should be done by rakes and no ramming allowed.

179. Explain the method used for calculating the forces acting on the bulkhead wall, both for and against stability.

The forces acting for stability are:

1. The weight of the submerged portion of the wall.
2. The weight of the portion of the wall not submerged.



The forces acting against stability are:

1. The weight of the submerged rip rap........	75
2. The weight of the submerged earth filling....	70
3. The weight of the earth filling not submerged	110
4. The weight of the rip rap not submerged....	110
5. Surcharge and liveload......................	1 000 lb. per sq. ft.

To find the thrust, reduce the quantities of the several materials to equivalents of the same material and find the resultant thrust as in case of a retaining wall. Combine this thrust through the centre of pressure with the weight of the wall through its centre of gravity and find the position of the resultant.

For complete discussion of bulkhead walls, see "Hoag on Dock Department of City of New York. *Proceedings* of Municipal Engineers, March, 1905.

180. When the foundation of a bulkhead is on rock, is any preparation of the rock ever necessary, and if so, what, and for what reasons?

The bulkhead foundation area is thoroughly dredged off and the holes, pockets and rock surface pumped clean by means of an 8 in. pump, and loose or disintegrated rock removed, divers being employed to assist in the work. Where the surface of the rock slopes evenly, it should be benched or stepped.

This treatment of the rock surface is necessary to secure a firm and lasting bond between the rock and the overlying masonry.

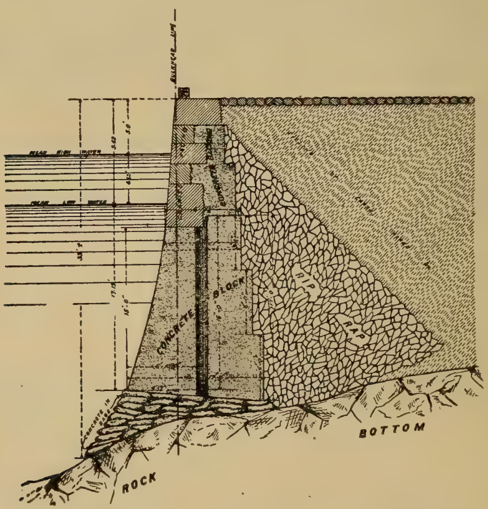
181. Where rock is near the surface, what type of wall is used?

Upon the prepared rock bottom concrete is laid up in bags, 3 ft. × 2 ft. × 8 in. to a surface having a slope towards the shore of 1 in 12.

Gravel concrete mortar is then used to even up the surface of the bags, which is then smoothed by means of heavy iron straight edges worked back and forth by divers. Upon this, the concrete blocks weighing about 70 tons are set, their dimensions being 17 ft. high, 6 ft. long, 12½ ft. wide at the base and 7 ft. at the top; they are stepped in the rear to make a good bond with the backing.

Upon the concrete blocks 5 courses (including the coping) of granite dimension stone masonry are set, starting about 2.5 ft. below mean low water to about 9.5 ft. above. The front batter is 1 : 12.

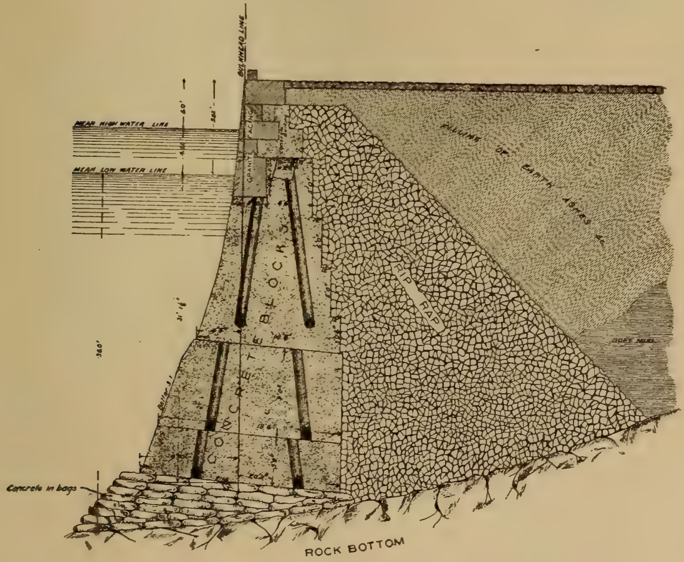
The dimension stone is backed with concrete and rip rap is deposited in back of the wall.



182. Describe the type of wall when the rock is 40 feet beneath the bed of the river.

In this case the foundation is prepared in a similar manner to the shallow rock wall as described in Q. No. 181.

Additional concrete blocks are used to bring the wall up to mean low water.



183. Make a sketch of the typical section of bulkhead in use at present where the bottom is good and depth moderate.

Where the bottom is firm the foundation area is dredged for a depth of about 20 feet, piles are driven to rock or to firm bearing and their tops cut off at about 15 feet below mean low water. The soft material in front and over the piles is removed and replaced with cobbles. A bed of mortar for the footing course is deposited around the piles. Upon this the wall is built and rip rap deposited in front and rear. (See Fig. 1, p. 130.)

184. Make a sketch of the section adopted where the bottom is soft to a considerable depth and without calculation explain fully the reasons for the adoption of the form and how it is that safety is secured by it.

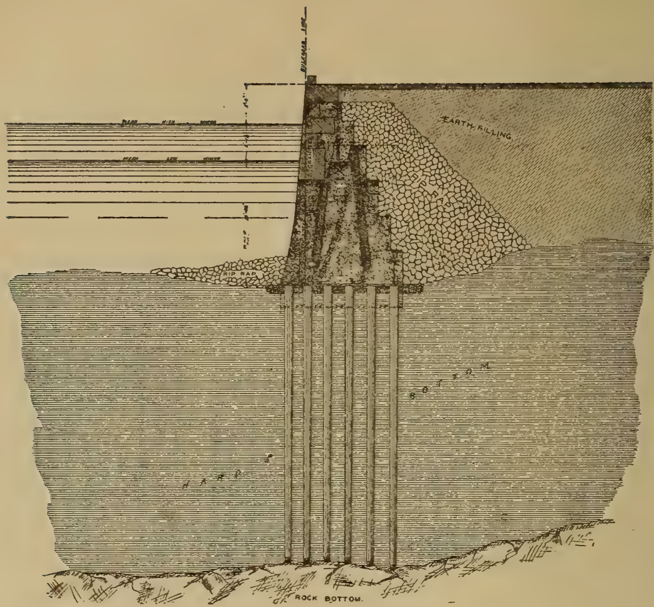

EARTH FILLING
RIP RAP
ROCK BOTTOM

FIG. 1.

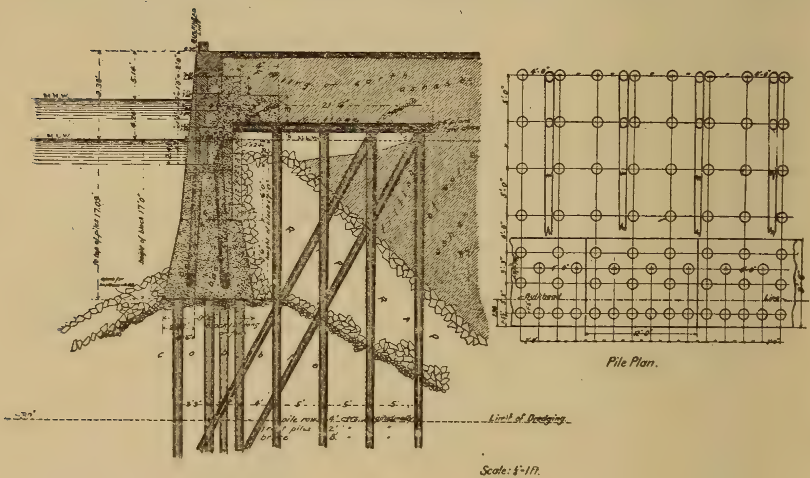

Limit of Dredging
Pile Plan.

FIG. 2.

When the bottom is soft for a great depth the wall is founded on piles driven to a firm bearing, spliced if necessary.

The tops of the piles are cut off about 15 feet below mean low water and surrounded with an embankment of rip rap, the material for some depth around the piles being dredged. Concrete is deposited on the rip rap and the wall built on the concrete base. In order to reduce the thrust on the wall proper, a "relieving platform" is built upon piles driven behind the wall. These piles are carried up above mean low water and braced by inclined piles.

The dimensions and arrangement of a typical section are shown in Fig. No. 2. The relieving platform permits the thickness of the wall itself to be reduced, resulting in a consequent saving in money and time of construction.

185. In using drift bolts for fastening timber, what precautions are necessary to obtain the greatest possible holding power in the timber?

The bolts should have a larger cross section area by about 25% than the holes into which they are driven, their ends slightly pointed with a hammer, and they should be of sufficient length to make a firm connection. Round bolts are preferable to square, as they do not tear the wood.

HIGHWAYS AND SEWERS.

186. Name the principal pavements used in city streets.

The principal pavements are:

Asphalt(sheet and block), Stone Block (cobble, Belgian and granite), Wood Block, Brick, and Macadam.

187. Describe the characteristics of a first class pavement for use in the city.

A good pavement should be impervious, hard, durable, noiseless and clean. It should afford a good foothold for horses, be adapted to all grades, and all classes of traffic. It should be cheap and easy to repair.

188. What are the advantages and disadvantages of principal kinds of pavements in use in the city?

Stone block pavements are durable, adapted to heavy traffic and steep grades, but they are not clean, are noisy, expensive and difficult to keep in good repair.

Macadam pavements are cheap, afford a good foothold, adapted to light traffic, but they are dusty and muddy, difficult to keep in order and costly to maintain.

Wood pavements are cheap, fairly clean, not noisy, afford good foothold; but may become slippery, are liable to swell and not easily repaired. They are also considered unsanitary.

Brick pavements are cheap, hygienic, clean, afford good foothold, but are liable to crack and are not durable.

Asphalt pavements are cheap, clean, noiseless and hygienic, but are not adapted to steep grades. They are liable to swell with heat, and are injured by fire and excessive amount of water.

189. What are the minimum and maximum allowable grades (*a*) for granite block pavement? (*b*) for asphalt pavement? (*c*) wood? (*d*) macadam?

	Minimum Grade.	Maximum Grade.
(*a*) Granite block........	1.5%	10% and over
(*b*) Asphalt.............	0.5%	$2\frac{1}{2}$%
(*c*) Wood...............	0.7%	5%
(*d*) Macadam...........	1.0%	5%

Grades outside of these limits are, however, occasionally employed.

190. Describe the steps of construction of a first class pavement and street to take the place of a common dirt road.

The road is first surveyed and cross sectioned, profiles prepared and grades (longitudinally and transversely) established.

The cross section is planned, showing the dimensions and character of the pavement and foundation.

The road is staked out, grade stakes being set at centre, curbs, house lines and slopes, with depth of cut or fill indicated.

The excavation for both curb and roadway is then made to subgrade. The bottom is drained, flushed, tamped, freed of all poor material (which is replaced with good soil or sand), and brought to an even surface parallel to the finished paving. The curbs should then be set.

Upon the subgrade a layer of concrete is spread for the foundation, having its top surface parallel to finished pavement.

Upon the concrete is spread a cushion layer of sand or a binder layer of asphalt and stone, depending upon the kind of covering to be used.

Upon this the final and finishing layer of blocks or asphalt is laid.

The construction of the sidewalks proceeds at the same time and in substantially the same order.

191. Describe the construction of a first class brick pavement.

The bricks should be of the best quality paving brick, annealed and $2\frac{1}{2}$ in. x 4 in. x 8 in. in size.

The street should be excavated to subgrade, all objectionable material removed and replaced by firm soil or sand, and the bottom watered and rolled, so that it will be parallel to the finished surface.

Upon this a layer of gravel and sand or concrete and sand is spread for foundation and cushion course.

The bricks are laid on the prepared bed of sand. They should be laid on edge at right angles to the axis of the street and break joints by 3 in. or more. No broken bricks should be permitted, except at closing points.

Before closing they should be compressed by iron bars and then keyed by close fitting bricks. After 25 or 30 feet of paving are completed, the bricks should be rammed with 50-lb. rammers and all low bricks removed and properly replaced.

The joints are then filled with sand, cement or paving pitch, and a layer of $\frac{1}{2}$ in. of dry sand spread over the entire surface.

192. State the essential points of a first-class stone block pavement.

1. Quality of the stones.—They should not be too hard, not capable of taking any polish and should afford good foothold for horses.
2. Size.—Depth should be about 7 in., width not more than 4 in., length 9-12 in. They should be well squared.
3. Foundation.—Should be constructed of hydraulic cement concrete, 4 in. to 9 in. thick, depending upon the character of the traffic.
4. Cushion course.—$\frac{3}{4}$ in., sand, clean, dry and free from pebbles, should be spread over the concrete.
5. Laying.—Should start at the sides and proceed toward the center and the whole keyed tightly. Joints should be broken and as narrow as possible. Blocks must be well rammed and low blocks removed and properly replaced.
6. Joints should be filled with paving pitch and gravel and a layer of sand should finally be spread over the blocks.
7. Blocks should be laid in parallel courses at right angles to axis of street.
8. At intersections the blocks should be laid diagonally or as usually called in the "Herring-bone" fashion.

193. State all the points to be observed in laying an asphalt pavement over an old cobblestone pavement.

The surface of old pavement should be thoroughly cleaned by sweeping with stiff brooms until all dirt, etc., has been removed from the surface and from the joints to a depth of about 1 inch.

The surface is then evened up and brought parallel to the finished grade by excavation if necessary, all depressions being filled with binder or concrete. Upon the blocks thus prepared a binder course is laid consisting of paving pitch and $1\frac{1}{4}$-in. broken stone, 1 gallon to the yard. The surface of the binder is made parallel to the finished surface. The stone used in the binder should be heated. The wearing surface of asphalt is then laid and rolled upon the binder to the required thickness, and is covered with a thin coating of hydraulic cement.

194. State all the essential points to be observed in preparing for and laying a Telford macadam road.

The foundation must be well drained, compacted and brought to a true, even surface parallel to finished pavement. Upon the surface thus prepared a layer of 8-in. stone is set by hand. A layer of broken stone (size less than 3 in.) is then spread evenly and rolled. Upon this is spread a layer of sand one-half inch thick and the rolling continued. A 4-in. layer of 2-in. stone or less is now placed and covered with a layer of sand. The final coat is a layer of clean, sharp sand, well watered and rolled. Macadam roads are constructed in substantially the same manner, except that the bottom course of 8-in. stone is replaced by broken stone.

195. (*a*) What are the principal requirements in relaying asphalt pavements?

(*b*) In relaying block pavements?

(*a*) In relaying asphalt pavements the sub-grade must be brought to a true surface well rammed and free from all objectionable matter.

The foundation course of blocks or concrete must be carefully laid and bonded with the adjoining portions of the old foundation. The binder is then put on. It should also be well bonded with the adjacent portion of the old binder. In joining the old work with the new, the old must be cleaned and stripped of disintegrated or loose portions and in the case of concrete thoroughly wetted.

The wearing surface is then laid and well tamped with hot irons where it joins the old work.

The new surface is thoroughly rolled until it presents a uniform appearance with the old.

In relaying block pavements the surface at sub-grade, as well as the concrete foundation and cushion coat, should be brought true and well tamped, so that when the blocks are rammed they will be firm and present an even surface without ruts or depressions. Sand must be used to adjust sub-grade when necessary. The blocks should fit properly and not work loose, and must be well bonded into the old pavement. The joints are then filled with pitch and gravel and a layer of sand spread over the new work.

196. Is an asphalt pavement injured by water standing upon it, and, if so, how does it deteriorate?

Yes. Asphalt pavements are disintegrated by standing water. This is most apparent in gutters and portions of pavement adjacent to fountain overflows. Rain and sprinkling does not affect the pavement if the water is quickly removed by evaporation or drainage.

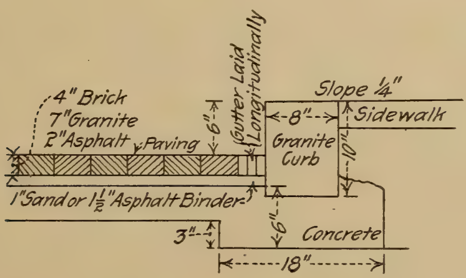
197. (*a*) What is the least grade that is desirable for the gutters of a street?

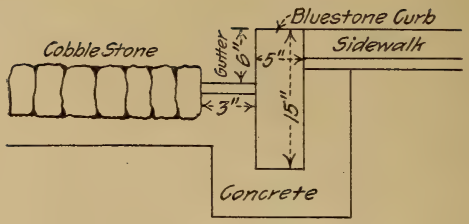
(*b*) Where the grade between two intersections is too flat, by what expedient may better grades be obtained without disturbing the cross-streets?

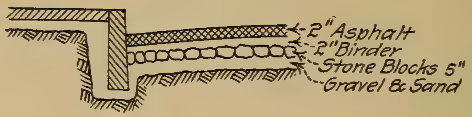
(*a*.) The least gutter grade is about ½%.

(*b*.) Accommodation summits are put at the center of the main streets, thus giving them a slight fall towards the crossings and causing the water to flow in both directions from the summit.

198. Give sketches showing three types of pavements.







199. What are the important principles that should be followed in the design and construction of sewers?

The sewer should be perfectly tight throughout its entire length to prevent leakage.

It should have a continuous fall, so that the flow will be uniform and also to avoid any tendency to deposit at particular points.

The sewers should be well ventilated, and none of the gases should be permitted to reach the buildings connected to them.

Means for inspection, cleaning and flushing the sewers must be provided.

The size and form should be properly proportioned, so that there will never be a too low velocity to cause deposition of suspended matter or too high a velocity to cause "scour."

The size should be ample to take care of the maximum flow, so that there will be no danger of back flow into the cellars or streets.

200. How would you measure the quantity of water flowing in a sewer?

The quantity of sewage carried depends upon:

The area of the sewage cross-section = A.

The wetted perimeter $= p$; $A \div p = r$.

The slope or grade of the sewer $= s$.

The condition of the interior surface.

These data can readily be obtained and substituted in the Chezy formula, $Q = c\sqrt{rs}$, which gives the discharge at once or the quantity can be taken directly from tables or diagrams prepared for the purpose with the above factors as arguments.

The velocity in the sewer may be measured directly by means of a float or a current meter, and the flow obtained by multiplying the velocity by the area of the sewage cross-section.

In large sewers temporary bulkheads and weirs may be constructed, over which the flow passes and the discharge obtained by the weir formula.

201. When is the velocity greatest in a sewer—when it is running full or half full, or how is it?

The velocity with respect to size depends upon the hydraulic mean radius, which is the ratio of the sewage cross-section to the wetted perimeter. In circular sewers this radius is the same for a flow full or half full. The velocity is therefore the same. In other sewers the velocity will depend upon the form of cross-section.

202. What is the least allowable velocity of flow in sewers, and why?

The velocity should not, in any case, be less than 2 feet per second in order to prevent the deposit of solid matter and consequent clogging of the sewer.

In sewers of very small diameters a greater minimum velocity (about 3 ft. per sec.) is required.

203. What is the minimum grade for 6-in., 8-in., 12-in. sewers, etc.?

Patton recommends the following:

For	6-in.	sewers,	grade	should	not	be	less	than	1 in 60
	9	"	"	"	"	"	"	"	1 in 90
	12	"	"	"	"	"	"	"	1 in 200
	15	"	"	"	"	"	"	"	1 in 250
	18	"	"	"	"	"	"	"	1 in 300
	24	"	"	"	"	"	"	"	1 in 400
	30	"	"	"	"	"	"	"	1 in 500
	36	"	"	"	"	"	"	"	1 in 600
	42	"	"	"	"	"	"	"	1 in 700
	48	"	"	"	"	"	"	"	1 in 800

204. For what rate of rainfall should sewers in New York City be designed? What proportion of this is assumed as reaching the sewer? Is it a constant, and show if you can how this is introduced in formulas for diameter of sewers?

The rate of rainfall in the vicinity of New York is taken at 1 in. per hour. One-half of this is usually considered as reaching

the sewer, but in paved streets 75% is not an unreasonable figure, and where the slope is very steep and rain of long duration 90% may reach the sewer.

The rate and proportion of rainfall reaching the sewer are factors in determining the discharge for any given drainage area and are introduced as y and c in the formula $Q = c\, y^4\sqrt{8\, A^3}$.

The formula for the diameters of sewers involves the quantity Q, and therefore y and c.

205. Show method of calculating sizes of outfall and lateral sewers, in the "separate system."

For calculating the sizes of sewers, tables or diagrams based upon the Kutter formula are commonly used.

The outfall sewer generally carries the flow for a large tributary population, the amount of flow being equal to the water consumption. One-half the total may be taken as discharging in 8 hours. The discharge per second is thus obtained.

The grade of the sewer or the velocity of flow may be assumed and the diameter corresponding to the assumed slope and the computed discharge is obtained directly from the tables or diagrams. If the sewer is to be oval its dimensions may be computed so as to give an equivalent flow to that of the circular sewer selected.

Lateral sewers are computed in substantially the same manner, the discharges used being dependent upon the population tributary to them.

206. Having a rainfall of 2 in. per hour in a well-paved, compactly built city, what size circular-pipe sewer having a fall of 2 ft. in 100 would be necessary to carry off the water from an area of 20 acres, assuming that all rainfall reaches the sewer? Show calculation or describe it; if you would use tables such as you would expect to have in your office, state just what the tables are, where they would be found, how you would use them.

The quantity of water reaching the sewer is calculated from the rate of rainfall and number of acres.

One inch of rainfall = 1 cu. ft. per sec. per acre. For 2 in. rainfall and an area of 20 acres, the discharge is $2 \times 20 = 40$ cu. ft. per sec., which the sewer must take.

To find the diameter, use a table giving mean velocities of flow for various slopes. With a slope of 2 ft. per 100 the diameter should be such that area of sewer section $\times$ the velocity = 40 cu. ft. per sec.

On inspecting Table, p. 279*c*, Trautwine, we note that a 2-ft. sewer is too small and a 3-ft. sewer too large. Taking a 2.5-ft. sewer, we find its hydraulic radius $= \frac{1}{4} \times 2.5 = 0.6+$. Area $= \frac{2.5^2}{4} \times \pi = 1.56 \times 3.1416 = 4.9$ sq. ft.

Use Formula $V = C\sqrt{r\ s.}$ $\begin{cases} V = \text{velocity, in feet per second.} \\ r = \text{hydraulic radius.} \\ s = \text{fall divided by length.} \\ n = \text{coefficient of roughness.} \end{cases}$

Table, p. 275, Trautwine, gives values of C for values of r. For a 2.5-ft. sewer, $C = 76$ ($n = .015$), giving $V = 76\sqrt{.6 \times .02} = .11 \times 76 = 8.3$ ft. per sec.

The area being about 5 sq. ft., the discharge will be somewhat over 40 cu. ft. per sec. The velocity is very high and special precautions must be taken to prevent wear of interior of sewer.

207. Would the sewer run full or partly full?

If left with you to decide, would you make this sewer a pipe sewer or an oval brick sewer? Why?

Under ordinary conditions the sewer would run *partly full,* because the total rainfall does not reach the sewer at once, as has been assumed in the computation. Also the rate of 2 in. per hour is very large and will not be reached during ordinary storms.

An oval brick sewer is preferable. During dry weather the flow is slight, and the oval shape permits a sufficiently high velocity to prevent deposits.

208. Does a sewer built to take the rainfall from 1 000 acres have to be ten times the size of one draining 100 acres, and give reasons?

No. In the formula the diameter varies as the 2/5ths power of the discharge, the discharge itself varying as the (Area) $\frac{3}{4}$. The relation between the size of the sewer and the area drained is thus not a direct one.

209. Calculate the diameter of a sewer required to carry off 1 in. of rain per hr. from 100 acres of land, the grade being 1 in 100. Assume the formula

$$D = \sqrt[5]{\frac{Q^2\ L}{1.5\ \ H}}$$

in which

Q = Cu. ft. discharged per sec.
L = Length of sewer, in feet.
H = Fall in feet.
D = Diameter, in feet.

1 in. per hr. = 1 cu. ft. per sec. per acre.
For 100 acres Q = 100 cu. ft. per sec.

$$D = \sqrt[5]{\frac{100^2}{1.5} \times \frac{100}{1.0}} = 1.46 \text{ feet.}$$

An 18-in. sewer should be used.

210. If a sewer of known dimensions was to be replaced by two smaller sewers of same grade and capacity, how would you obtain dimensions of same?

Each smaller sewer would have to take care of half the discharge of the original sewer.

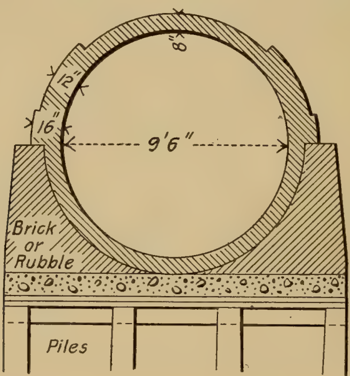
Using the new discharge and the same grade select from appropriate tables the diameters which give the discharge, or apply the new discharge in the formula and compute the diameter.

211. State what is understood by the separate and by the combined system of sewerage and give as you understand them the reasons why one or the other would be best to use in any case.

In the separate system the house drainage is carried in one system of sewers and the rain water in another, while in the combined system both sewage and storm water discharge through the same set of channels.

Where the sewage does not have to be purified before discharging the combined system is more economical, but where purification must be resorted to it is necessary to have the separate system to reduce the quantity treated at the purification plant. In any city the selection of one system or the other will depend upon the local conditions and the amount of money available.

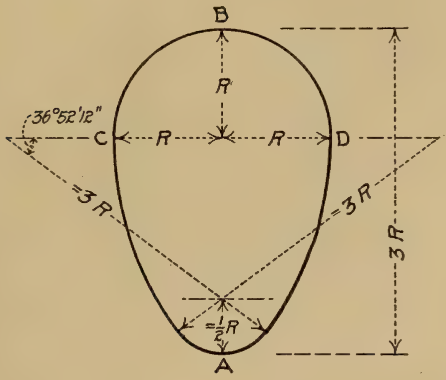
212. Give a sketch showing a cross section of a large brick sewer with dimensions, which is to be built across a piece of soft ground.



213. When would you use the egg-shaped section for sewers?

Egg-shaped sections are used in the combined system where the sewers are designed to carry both sewage and storm water. The smaller section at the bottom gives a higher velocity over other forms when the flow is small and thus prevents deposition of sediment during dry weather flow.

214. Sketch an oval sewer, *i. e.,* egg-shaped, and give radii of all arcs in terms of the radius of the arch.



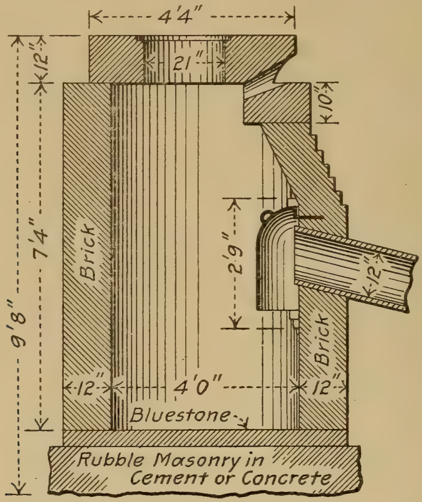
215. What is the largest size of vitrified pipe sewer in use? Describe the precautions for laying them so as to secure the freest flow in a sewer of small descent.

Thirty-six inch are the largest vitrified pipes used. The pipe should be laid to a uniform grade, containing no irregularities or depressions. The laying of the pipe is begun at down-stream end of the line. The pipe is laid on a proper foundation with the hub end facing up stream. The spigot end of each successive pipe is fitted into the hub already set to line and grade, and the joint thoroughly filled with cement mortar. The operation of laying is carefully made so that the invert will be smooth and true. The refilling of the trench must be done in a careful and thorough manner to prevent any undue strain or jar on the pipes.

If expense permits, a foundation of planks or concrete will add to the service and life of the sewer.

216. What is a catch basin, and what is its use and locality? Sketch one adapted for use in the city.

A catch basin is a well or chamber designed to receive storm water or surface drainage before the latter enters the sewer, its object being to catch the solid matter, etc., washed in from the surface. It is located usually at or near street corners or curb lines.



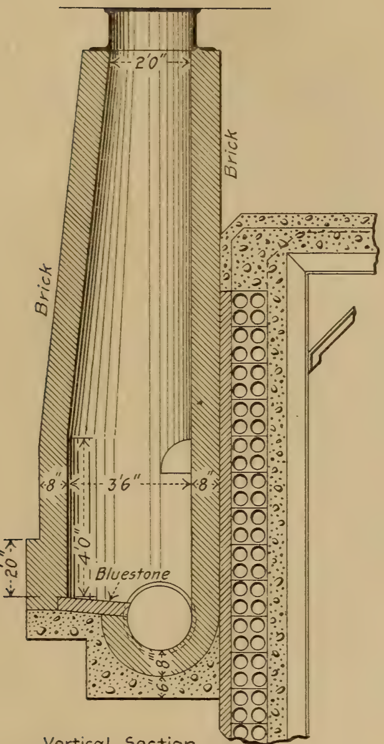
217. What is a manhole and what is its use? Sketch one and show construction.

A manhole is a shaft, usually masonry, leading into a sewer from the street surface. It is large enough to permit access to sewer for purposes of examination and cleaning and also provides means of ventilation. (See sketch, p. 143.)

218. How frequently should catch basins be placed along a street, and what rule governs this? How frequently should manholes be placed?

Catch basins should be placed at all low points in the street where considerable water is apt to collect. On long grades catch basins are placed at every street intersection where the grade of the intersecting streets permit.

Manholes should be placed every 100 ft. for small sewers; for large sewers this distance may be increased from 200 to 500, depending upon their size. They should be frequent enough to permit cleaning and afford proper ventilation for the sewers.



Vertical Section
through Straight Manhole.

AUTHORITIES CONSULTED.

Trautwine's Civil Engineer's Pocketbook.
Patton's Civil Engineering.
Merriman's Hydraulics.
Fanning's Water Supply.
Baker's Masonry.
Byrne's Highway Construction.
Bryne's Inspector's Pocketbook.
Hoag on Dock Department of New York City (*Proceedings* Municipal Engineers, March, 1905.)
Reports—Commission on Additional Water Supply.
Kent's Mechanical Engineer's Pocketbook.
Johnson—Theory and Practice of Surveying.
Pence & Ketchum—Surveying Manual.
Wegmann—High Masonry Dams.
Wegmann—History of Water Supply of New York City.
Catalogue—Associated Expanded Metal Cos.
Buel & Hill—Reinforced Concrete Construction.
Stauffer's Modern Tunnel Practice.
Burr's Theory of the Arch.
Folwell's Sewerage, Etc.

APPENDIX.

SOME USEFUL ENGINEERING FORMULAS.

NOTE.—The collection of formulas included in this volume is not intended to be complete in any sense, but it contains a fairly comprehensive list of the more common engineering formulas with which candidates ought to be familiar, and it will serve as a ready reference to those preparing themselves for examinations.

For Uniform Motion:

$$v = \frac{s}{t}; \quad s = v\,t; \quad t = \frac{s}{v}.$$

v = velocity in feet per second.
s = space in feet passed over.
t = time in seconds.

For Falling Bodies:

$$v = g\,t = 32.16\,t = \sqrt{2\,g\,h} = 8.02\,\sqrt{h} = \frac{2\,h}{t}.$$

$$h = \frac{g\,t^2}{2} = 16.08\,t^2 = \frac{v^2}{2\,g} = \frac{v\,t}{2}.$$

$$t = \frac{v}{g} = \sqrt{\frac{2\,h}{g}} = \frac{\sqrt{h}}{4.01} = \frac{2\,h}{v}.$$

v = velocity in feet at the end of t seconds.
g = acceleration due to gravity = 32.16 ft per sec. per sec.
h = space in feet passed over in t seconds.

$$F = M\,a \qquad M = \frac{W}{g}$$

Momentum $= M\,v$.

Work or Energy (in foot-lbs.) $= F\,s = \frac{1}{2}\,M\,v^2 = \frac{W\,v^2}{2\,g}$.

Power (in foot-lbs. per sec.) $= \frac{F\,s}{t}$.

F = force in lbs.
M = mass.
a = acceleration.

W = weight in pounds.
v = velocity in feet per second.
t = time in seconds.
g = 32.16.

Angular Velocity :

$$A = \frac{v}{R} = \frac{2\ \pi\ N}{60}.$$

Centrifugal Force :
(in lbs.)

$$f = \frac{W\ v^2}{g\ R} = .000341\ W\ R\ N^2.$$

A = angular velocity per second.
v = linear velocity of center of gravity of body in feet per sec.
R = radius in feet of curved path.
π = 3.1416.
N = number of revolutions per minute.
W = weight of revolving body in pounds.
g = 32.16.

Pressure of Water.

$p = w\ h = .434\ h$ lbs. per sq. in. $= 62.5\ h$ lbs. per sq. ft.
$h = 2.31\ p.$
$P = w\ A\ d = \dfrac{w\ h^2}{2}$ on rectangular vertical surfaces (one foot wide.)

p = intensity of pressure.
P = total pressure in pounds.
A = area of submerged surface.
d = head on center of gravity.
h = total depth of water in feet.
w = weight per unit of water.

Center of Pressure :

When not submerged $= \frac{2}{3}$ of depth below surface.
" submerged $= \frac{2}{3}\ \dfrac{h_1^{\,3} - h_2^{\,3}}{h_1^{\,2} - h_2^{\,2}}.$

h_1 = head on bottom of submerged surface.
h_2 = head on top of submerged surface.

Flow of Water:

$$v = \sqrt{2\ g\ h}; \qquad h = \frac{v^2}{2\ g}; \qquad Q = A\ v.$$

v = velocity in feet per second.
g = 32.16.
h = head in feet.
A = area in square feet.
Q = theoretical discharge in cubic feet per second.

Flow through Orifices:

$$Q = c\,A\,v = c\,A\sqrt{2\,g\,h}.$$

c = 0.60 to 0.90 = constant depending upon conditions of flow.

Flow over Weirs:

When there is no velocity of approach,

$Q = 3.33\,b\,H^{\frac{3}{2}}$ (no end contractions).

$= 3.33\,(b - 0.2\,H)\,H^{\frac{3}{2}}$ (end contractions.)

b = length of weir.
H = head on crest.
Q = discharge in cubic feet per second.
If h = head causing the velocity of approach,

then $Q = 3.33\;b\;[(H + h)^{\frac{3}{2}} - h^{\frac{3}{2}}]$ (no end contractions).

$Q = 3.33\,(b - 0.2\,H)\;[(H + h)^{\frac{3}{2}} - h^{\frac{3}{2}}]$ (with end contractions).

Flow through short pipes (length = 3 diameters):

$$Q = c\,A\,v; \qquad c = 0.80 \pm.$$

Flow through Pipes:

$$Q = 0.7854\,d^2\sqrt{\frac{2\,g\,h}{1.5 + \frac{f\,l}{d}}} \qquad d = 0.479\sqrt[5]{\frac{f\,l\,Q^2}{h}}.$$

Q = discharge in cubic feet per second.
f = coefficient of friction = 0.02 (trial value).
l = length of pipe in feet.
d = diameter in feet.

For open channels on very long pipes:

$$Q = A\,v = A\,c\sqrt{r\;s}\ \text{(Chezy formula)},$$

in which $c = \dfrac{\dfrac{1.811}{n} + 41.65 + \dfrac{0.00281}{s}}{1 + \dfrac{n}{\sqrt{r}}\left(41.65 + \dfrac{0.00281}{s}\right)}$ (Kutter's formula),

A = cross-section area of conduit, etc., in square feet.
c = empirical constant.

r = mean hydraulic radius.
s = sine of slope of water surface.
n = constant 0.01 to 0.03, depending on roughness of surface.

High Masonry Dams:

Thrust $= \frac{1}{2} w h^2$.
Moment of thrust $= \frac{1}{6} w h^3$.
Moment of resistance to sliding $= W f$.
Moment of resistance to overturning $= W c$.
w = weight per cubic foot of water.
h = depth of water in feet.
W = total weight of dam above the horizontal plane considered.
f = coefficient of friction of masonry on masonry.
C = distance from center of gravity to center of pressure at the horizontal plane in question.

Unit Pressure:

For uniform loads, $p = \frac{W}{A}$.

For maximum pressure, $p = \frac{w(L - - d)}{L d} = \frac{2W}{3d}$.

To find number of small pipes of diameter d to replace single pipe of diameter D,

$$\text{No.} = \sqrt{\frac{D^5}{5}}$$

Run-Off:

$$Q = \sqrt[4]{S A^3}$$

Q = discharge in cubic feet per second.
S = slope of drainage area in feet per thousand.
A = drainage area in acres.

Culvert Opening:

$$A = c \sqrt[4]{M^3}.$$

A = area of opening in square feet.
c = constant ($\frac{1}{6}$ to 1.0, depending upon topography).
M = drainage area in acres.

Strength of Materials:

$$S = \frac{P}{A} \qquad s = \frac{e}{l} \qquad E = \frac{S}{s} = \frac{P\,l}{A\,e}$$

S = unit stress, in pounds per square inch.
P = total stress, in pounds.

A = area of cross-section, in square inches.
s = elongation per inch.
e = total elongation, in inches.
l = length, in inches.
E = coefficient of elasticity.

Beams:

$$I = A\,r^2 \qquad M = \frac{S\,I}{c} = S\,\frac{b\,d^2}{6} \text{ for rectangular beams.}$$

I = moment of inertia.
r = radius of gyration.
M = moment of resistance of beam.
S = horizontal unit stress.
c = distance of outermost fiber to neutral axis.
b = width of beam.
d = depth of beam.

Columns:

$$p = \frac{s}{1 + \frac{l^2}{g\,r^2}}$$

p = unit stress, in pounds per square inch.
s = ultimate strength in compression.
l = length of column.
r = least radius of gyration.
g = empirical constant.

Thickness of Pipe:

$P\,D = 2\,s\,t$

P = unit pressure, pounds per square inch.
D = diameter of pipe, in inches.
s = working stress, in pounds per square inch.
t = thickness of pipe, in inches.

Arch:

Trial depth of keystone, in feet $= \frac{\sqrt{r + \frac{1}{2}s}}{4} + 0.2$ (Trautwine).

Width of abutment at springing $= \frac{r}{5} + \frac{r'}{10} + 2$.

r = radius of arch, in feet.
r' = rise of arch, in feet.
s = span of arch, in feet.

Pressure Against Retaining Wall:

$P = 0.643\ W$

P = total pressure against wall.

W = weight of prism of earth within plane of maximum thrust.

Piles:

$$L = \frac{2\ w\ h}{s + 1}$$

L = safe load, in pounds.

w = weight of hammer, in pounds.

h = fall, in feet.

s = average settlement of last blows, in inches.

MANUAL OF EXAMINATIONS

FOR

ENGINEERING POSITIONS

IN THE

SERVICE OF THE CITY OF NEW YORK

QUESTIONS AND ANSWERS

IN *3* VOLUMES.

VOL. I. AXEMAN, CHAINMAN AND RODMAN, LEVELER TRANSITMAN AND COMPUTER.

VOL. II. ASSISTANT ENGINEER.

VOL. III. DRAFTSMAN, AND INSPECTOR.

VOL. III. PART I.

DRAFTSMAN AND DRAFTSMAN'S HELPER.

INDEX

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THE ENGINEERING NEWS PUBLISHING COMPANY.

1906.

J. F. TAPLEY Co.
BOOK MANUFACTURERS
NEW YORK

PREFACE.

In the "Previous Examination Papers," which have been included in this book, the questions may not, in all cases, be identical in wording with those actually given at the examinations, as copies of the original papers are not readily procurable, but they do embody the substance of the questions asked.

In the section devoted to "Typical Questions and Answers," great care has been taken to make the answers conform with the best modern practice. Reasonable variance of opinion may exist as to what is the best answer, owing to differences in interpretation of the question and in education and experience, but it is sufficient to say that the answers given are based on such recognized authorities as Reinhardt's "Technic of Mechanical Drafting," Pence and Ketchum's "Surveying Manual," Prof. Burr's books on Bridge Design, and Gillespie's "Surveying."

In order to perpetuate the value of the book, blank leaves have been inserted after the "Previous Examination Papers," allowing for the convenient addition of new sets, and the "Typical Questions and Answers" have been interleaved to provide space for notes, sketches, and additions.

PREVIOUS EXAMINATION PAPERS.

DRAFTSMAN'S HELPER.

Salary, $600 to $1,200.

1. What do you understand to be the duties of junior assistant draftsman?

2. How are original drawings reproduced so that various copies may be sent to contractors, or used on construction?

3. What kinds of materials would the following colors indicate on drawings: (*a*) blue gray, (*b*) red, (*c*) purple, (*d*) blue, (*e*) slate, (*f*) light blue, (*g*) yellow?

4. How many general drawings are needed in ordinary building work, and what are they?

5. What scale is used for (*a*) general drawings; (*b*) detail drawings for school buildings?

6. How do the sides of tracing cloth differ? What is the advantage of using each side as compared to the other?

7. After having to erase ink on tracing cloth, how can you prevent the new ink from running?

8. How is the blue print made from a tracing?

9. What is a "T" square and how is it used?

10. Describe the two "triangles" most used and how lines perpendicular to the drawing board can be ruled with them.

11. Why should ink on the outside of a right line ruling pen be wiped away? What is the best way of getting ink on a right line ruling pen?

12 and 13. Draw neatly a column with ornamental cap and base.

14 and 15. Reproduce in your best style lettering: Front Elevation, Grammar School No. 35, Scale $\frac{1}{4}$ in. to 1 ft.

Arithmetic.

1. How many pieces of tracing cloth 24 in. by 36 in. can be cut from a roll, 60 in. wide, and 24 ft. long? How many from a roll, 48 in. wide and 24 ft. long?

2. How many brick, allowing 21 to a cubic foot, are in a brick wall 20 in. thick, 21 ft. high and 46 ft. long?

3. Multiply 231 by 672 and take $23\frac{1}{2}\%$ of the product.

4. Add 42 ft. 6 in., 16 ft. 2 in. and 15 ft. 3 in.

DRAFTSMAN'S HELPER.

TECHNICAL.

1. What do you understand to be the duties of assistant draftsman?

2. What scale is usual for (*a*) general drawings; (*b*) detail drawings for school buildings?

3. Name all the general plans necessary to show the character of construction of a steel frame building.

4. What colors are used to indicate the following materials: (*a*) iron, (*b*) wood, (*c*) plaster, (*d*) concrete, (*e*) granite, (*f*) fire brick, (*g*) bronze and copper, (*h*) fire-proofing?

5. How are contemplated alterations of an existing building shown on plans?

6. How are water colors mixed and applied to secure uniform tints and neat appearance?

7. Show by sketches, form and dimensions of a cast-iron lintel for an opening 4 ft. 6 in. wide.

8. Explain the following terms as used in carpentry specifications: (*a*) Centers (for mason); (*b*) furring; (*c*) wedging; (*d*) trim.

9. Explain the following terms used in masonry specifications: (*a*) Flemish bond, (*b*) stone template, (*c*) wash (of sills), (*d*) drip (of cornice).

10. (*a*) What is a column; (*b*) a pilaster?

11. Draw neatly a column with ornamental cap and base.

12. Draw neatly a design for an ornamental iron railing for a balcony.

13. Draw neatly two arched windows, one beyond the other, divided at an angle of 45°, showing perspective.

14 and 15. Arrange and complete enough letters to show skill at lettering the following: "Front Elevation, Grammar School 35, Department of Education, City of New York, Scale ¼ in. to 1 ft."

ARITHMETIC.

1. Subtract 196 ft. 9½ in. from 274 ft. 7¼ in.
2. Cubic measure.
3. Multiplication.
4. Addition.

DRAFTSMAN'S HELPER.

Technical.

(Sketches or drawings may be done in ink or pencil).

1. Define and illustrate by sketches of a table (*a*) plan, (*b*) elevation, (*c*) middle vertical section.

2. Make a neat tracing of these sketches.

3. Draw neatly a box 10 ft. long, 4 ft. high and 6 ft. wide in perspective with one corner toward you.

4. What is the method of stretching drawing paper preparatory to using colors? How should colors be applied?

5. (*a*) How is tracing cloth treated to prevent drawing ink from running? (*b*) Which side of tracing cloth should be used?

6. How are blue-prints made?

7. Show three different methods of indicating the scale of a drawing and state which is best, with reasons.

8. How long a piece of drawing paper will be required for a map of a small park 430 by 250 ft. to a scale of 1 in. equals 50 ft.?

9. (*a*) What is the difference between an inch and a tenth of a foot? (*b*) Between 3 sq. ft. and 3 ft. square?

10 and 11. Indicate by quickly made but neat drawings: (*a*) a wooden beam, (*b*) concrete, (*c*) rock-faced masonry, (*d*) random coursed masonry, (*e*) a Corinthian column cap, (*f*) a Doric column cap, (*g*) a frieze.

12. What colors are used to indicate (*a*) wood, (*b*) concrete, (*c*) common brick, (*d*) iron work, (*e*) earth.

13. Describe two ways of laying off an angle, one of which is the most accurate way. Give reasons why it is so.

14 and 15. Draw neatly the following in your best style: ABC abc 123 (in any quick, plain style); EGM egm 456 (in substantial block or Roman style); OQS oqs 789 (in round writing or Gothic style).

Arithmetic.

1. Add 29 ft. $7\frac{1}{2}$ in., 11 ft. $\frac{3}{4}$ in., 7 ft. $\frac{7}{8}$ in., 6 ft. $9\frac{5}{8}$ in., and 17 ft. $11\frac{5}{16}$ in.

2. Reduce 2 $463\frac{3}{4}$ in. to feet and decimals of a foot.

3. Subtract from the answer of (2) 122.6875 ft. and reduce the result to inches.

4. How many cubic yards are there in a wall 207 ft. 6 in. long, 3 ft. thick, 12 ft. high at one end, and 6 ft. high at the other?

5. What is the area of metal in a cast-iron column 8 in. outside diameter and 1 in. thick?

TOPOGRAPHICAL DRAFTSMAN.

Salary, $1,200 to $1,800.

TECHNICAL.

1. (*a*) What drawings does a topographical draftsman have to make?

(*b*) Suppose there were notes of a closed survey of a field, how would he examine them as to their reasonable correctness?

2. If errors are found in latitudes and departures (*a*) how would tabular corrections be applied? (*b*) How can the amount and direction to be applied at the end of each course be determined graphically?

3. (*a*) If the course and length of one side be missing how can it be supplied? (*b*) Is any assumption made by doing this, and if so, what is it?

4. (*a*) How many square chains (of 66 ft. per chain) are there in an acre? (*b*) How many square feet are there in an acre?

5. How should a drawing of a survey be located on the paper?

6. (*a*) When a transit survey of a street or other continuous survey of considerable length, and with a number of angles in it, is to be plotted, what method should be pursued to avoid as far as possible errors in plotting? (*b*) What is the most accurate method of laying off an angle on paper?

7. Illustrate all the ways of indicating, either by description or otherwise, the scale to which a drawing is made.

8. In a reverse curve, are there any trigonometrical lines common to the two branches of the curve, and if so, what are they?

9-10. Make a careful trigonometrical drawing about 2 in. square, in your best style, of a portion of a hill, containing two ravines or depressions approximately parallel, starting from nothing a little below the top and reaching a considerable depth before debouching upon the plain below. A swelling ridge to occupy the space between the ravines. All slopes to be represented by hachures.

11-12. Make a careful topographical drawing 2 in. square of a reservoir and dam, with wide stream above and below.

13-14. Draw the same of a farm, with one-quarter in evergreen trees, one-quarter in hardwood trees; the rest showing buildings, orchard, meadows, etc.

15. Show your skill in lettering and arrangement by drawing a caption to a drawing as follows:

"Map of a part of the Borough of The Bronx.
March, 1902.
Scale 100 ft. per inch."

Arithmetic.

1. Compute the areas of a hexagon of which the radius of the circumscribed circle is 11 ft.

2. Extract the square root of the following number, 70913.078.

3. Find the sum of $3\frac{2}{5} + 4\frac{1}{8} + 1\ 11\text{-}40 + 3\ 18\text{-}265$ and express the fractional portion in decimals.

4. A field is trapezoidal in shape with one end at right angles to the two parallel sides. The parallel sides are respectively 713 ft. and 1 619 ft. long, and the inclined end has a length of 1 278 ft. What is the area of the field?

TOPOGRAPHICAL DRAFTSMAN.

1. (*a*) What information should be furnished by a well prepared topographical map? (*b*) For what purposes are topographical maps used in this city?

2. Describe how the area of a piece of land is determined by (*a*) the use of a planimeter; (*b*) by "double meridian distances." (*c*) What other method is used?

3. How should the scale to which a map is drawn be shown?

4. In computing the parts of a triangle, how many different cases may arise; to which one may two correct answers be given, and under what conditions?

5. A piece of property 500 ft. square shows elevations taken every 100 ft. as follows:

100—105—115—115—120—120
105—115—120—120—130—120
115—118—130—140—140—130
115—120—125—130—130—120
112—115—115—125—120—115
118—112—110—118—110—110

Plot this to approximate scale and show contours at 5-ft. intervals, beginning at elevation 100.

6. Assuming that you are to plot a course running 1 060 ft. N. 16° 40′ W. Describe two ways of doing it, one of which must be accurate, and state why it is so.

7 and 8. Show 10 000 ft. of a profile of center line of a sewer, with grade 0.25%, running under rough ground. Make vertical scale 1 in. equal 10 ft., horizontal scale 1 to 2,000. Show all necessary information.

9. Make topographical drawings 2 in. square in your best style, with pen or pencil, of a country road on a hillside heavily wooded; show a bridge and small stream. Scale about 1 in. = 30 ft.

10. Same for mill pond, showing dam and mill, and using contours. No special scale necessary.

11. Same for precipitous bluff and ravine by hachures.

12. Same for a small park, showing evergreen and deciduous trees.

13. Draw neatly in your best style (with pen or pencil) the following caption. Lay out the work carefully as to spacing and ar-

rangement and complete at least two letters of each line: "Map of Stapleton and Vicinity, Borough of Richmond, City of New York, from Surveys made in 1903. Scale: 1 inch to 500 feet."

Mathematics.

Give all the figuring on the ruled sheets.

1. Demonstrate that the side of an equilateral triangle inscribed in a circle is to the radius, as the square root of 3 is to unity.

2. Extract the square root of $\frac{4483}{6887}$; give the answer in a decimal, correct to three places.

3. A walk 9 ft. wide surrounds a square garden, the area of the walk being $\frac{1}{4}$ of an acre, what is the length of a side of the enclosed square?

4. A city lot in the form of a trapezoid costs $2 250 at 40 cents a square foot. If its parallel sides are 39 ft. and 57 ft., what is its length?

TOPOGRAPHICAL DRAFTSMAN.

1. What are contour lines, what rules govern the use of same, and how may one contour line cross another?

2. Describe the best method of plotting boundary lines of a survey.

3. What can be said of a closed survey as to possible error? How would you examine the surveying notes as to their correctness?

4. How would you distribute the errors?

5. What errors are allowed in country, railroad and city surveys?

6. Give the trigonometrical functions by diagram and state the relations between sine, cosine, tangent and secant, giving their equivalents.

7. Draw a profile of a country road 1 000 ft. long with horizontal scale of $1'' = 100'$ and vertical scale of $1'' = 10'$, giving proposed grade line, elevations and all features usually noted on a profile.

8. In a square of 2 in. draw a pond with in- and out- going stream, marshy shore, and wooded small island.

9. In a square of 2 in. draw farmhouses, with outhouses, cornfield, ploughed ground and wooded land.

10. In a square of 2 in. draw sandy shore, with steep hills and ravines shown by contours, railroad, pine and oak trees.

11. Draw a title as follows, using your best judgment as to the size of letters, spacing and general arrangement: "Topographical Map of the Borough of Queens of the Greater City of New York from surveys made in 1897, Scale 1 inch = 100 feet."

Mathematics.

1. If a side of a hexagon is 25 ft., what is the diameter of a circle having the same area as the hexagon?

2. Divide 1092.304 by .00352; give square root of quotient.

3. Get the value of the following: $\frac{7}{8}$ of $7925 \times \frac{3}{4}$ of .0052; give square root of product to 3 decimal places.

4. A strip of land has two parallel sides, 785 and 1 979 ft.; distance between sides is 75 ft.; what is the area?

TOPOGRAPHICAL DRAFTSMAN.

NOTE.—All sketches are to be neatly done with pen or pencil.

1. Give the usual diagram showing the cosine, tangent, cotangent, secant, and cosecant of an angle, designating each by two different letters.

2. State and describe briefly the different kinds of surveys necessary to furnish data for a topographical map.

3. State three different methods of determining the area of a piece of land which has been plotted.

4. Give the notes of a boundary survey of a piece of property; describe how you would plot them and show graphically how you would distribute an error of closure.

5. (*a*) Why is it not best to use a protractor to plot such a survey? (*b*) How would you look for a considerable error in angles in such notes?

6. Describe a traverse table and its use.

7. What form of notes would you require to enable you to plot an irregular shore line of a river or lake?

8. Describe the method of plotting a course of a survey by chords.

9. (*a*) Show by sketches two methods of showing the scale of a drawing 100 ft. to 1 in. (*b*) Show by sketch the method of indicating the points of the compass on a map.

10. Draw a small topographical map, 2 in. square, of two small hills, with a brook with steep banks between, running out through a nearly level meadow; show contours.

11. Same by use of hachures.

12. Same of a river with marshy shore on one side and sandy shore, steep bank, wooded with several varieties of trees on the other.

13. The same for part of a farm, with ploughed land, cultivated land, orchard and buildings.

14 and 15. Show your skill in lettering by arranging the following title and finish at least four letters of each line: "Map of Blackwell's Island, Borough of Manhattan, Greater City of New York, from survey made in 1872. Scale 100 ft. to 1 in."

TOPOGRAPHICAL DRAFTSMAN.

April 12, 1897.

1. Describe fully and clearly what is meant by the term topography.

2. Draw as well as you can, in ink, an example about 1 in. square of each of the following objects: (*a*) A pond or lake; (*b*) two hills with intervening valley; (*c*) a stream with a branch entering it; (*d*) marshy ground; (*e*) an orchard; (*f*) woods; (*g*) a common road with stone fences and a railroad crossing it. Place the letter indicating each over it.

3. Draw in ink a complete profile of a street 1 000 ft. long, showing the natural ground, streets crossed, the grade line, with breaks, if any, all to be finished completely and thoroughly as it would be in an actual case, giving every figure and all information that should be shown. (Do this lengthwise of the sheet.)

4. Notes have been handed you of a land survey and you are directed to compute the quantity and make an accurate map of same; give the form of table you would use, explain the meaning of the several quantities and how they are used.

5. If the drawing mentioned in Question 4 is to be made on a large scale, state how you would distribute the errors in angles and measurements along the several angles and sides so as to make your drawing close.

6. Suppose the property in question to be very valuable, how much error in line and angle would you consider to be consistent with careful field work?

7. Having the courses and distances of all the sides of a piece of ground but one, how can you supply the missing data?

8. In locating a survey upon a map, how should the north and south line be placed?

9. In making a plot of a piece of ground (all errors of survey having been balanced), what is the best method of doing it to reduce the error of plotting to a minimum?

10. What is the best way of indicating a scale of a drawing upon it?

11. Show by sketch the location of the sine, cosine, tangent, cotangent, secant and cosecant of an angle of about 30°, giving reference to each by letter.

12. In a right-angle triangle, of which the base is (*b*), the vertical leg (*a*), and the hypothenuse (*c*), give the values of the sine, cosine, tangent and cotangent.

13. In a very small triangle, which of these increase most in error as the angle increases?

14. Describe the several parts of a logarithm and how logarithms are used in making computations.

15. A field has a side $A\ B$ parallel to $C\ D$ and the angles at A and C right angles. It is desired to divide it into two equal parts by a line parallel to $A\ B$. Give the distance on $A\ C$ from A to the given line.

TOPOGRAPHICAL DRAFTSMAN.

AUGUST 10TH, 1904.

1. What are "contours," "hachures"? Illustrate by hachures a ravine between two hills.

2. Describe how a topographical survey for a water-shed would be made with transit and stadia.

3. Give mathematical relations between sine, cosine, tangent, cotangent and secant.

4. Give a form of notes for running levels of the center line of a street at least 1 000 ft. long.

5. Give a form of notes for a survey with transit and stadia. Explain same.

6 to 7. From given bearings and lengths make a table for balancing the survey and describe how the balancing is done and how area is computed in acres. Use the method of co-ordinates. Also explain why some values are additive and some are subtractive.

8. Give the elevation of points 50 ft. apart; draw in contours at intervals of 5 ft.

9. How do you find the area of a plot which is bounded on one side by an irregular shore line?

10-13. In a space 6″ by 4″ show the following standard topographical signs: (*a*) A pond with a marsh on one side; (*b*) with a meadow adjacent; (*c*) ploughed land and cornfield; (*d*) the other shore sandy, with a bluff wooded with oak and pine.

14-15. Correct, arrange and lay out the following title, finishing enough letters to show skill in lettering: Topographical map of the Borough of Queens, the Greater City of New York, from surveys made in 1904, scale ________. Indicate the scale to be used for such a map.

ARITHMETIC.

1. Extract the square root of 25.0$\frac{3}{4}$.

2. Find the length of arc of 30° in a circle whose radius is 10 ft.

3. Find area of above sector.

4. Divide decimal fractions and multiply result.

5. Find the area of triangle whose sides are 40′, 30′ and 60′.

TOPOGRAPHICAL DRAFTSMAN.

Technical.

October 31, 1905.

1. How would you proceed to enlarge a map so as to be able to fill in additional details?

2. How would you plot the survey of a line of considerable length with a number of angles, so as to avoid error in plotting the angles?

3. What notes should you receive in order to plot a curve, such as a railroad, and how would you do it?

4. (*a*) How many square chains are there in an acre? (*b*) How many square feet in an acre?

5. Describe the planimeter and its use.

6. (*a*) What notes should you receive to enable you to locate an irregular shore line? (*b*) How would you compute the area of a piece of property bounded by an irregular shore line?

7. Show a form of stadia notes and state what reductions have to be made in the office.

8 to 12. Make a neat drawing in ink or pencil of a city block 200 by 400 ft. to scale 50 ft. equals 1 in. Show one end with rocky cliff and sandy beach and shore line, the other end with city lots and several houses; the main portion an old residence with grounds, outbuildings, driveway, pine and oak trees, a fruit orchard, garden and cornfield.

13. Arrange the following caption and fill in the letters underlined in your best style, using at least three kinds of lettering: Topographical map of Bronx Park, Borough of the Bronx, City of New York, from Surveys made in 1903. Scale 100 ft. to 1 in.

Mathematics.

Give all the figuring on the ruled sheets.

1. Extract the square root of 4930.6271.

2. What is the area of a triangle of which the sides are 50, 60 and 70 ft.?

3. Add 17 ft. 11½ in., 4 ft. 7 in., 13.375 ft., 35½ in., 16 ft. 9 in., and ½ ft. Express the result in feet and inches, and feet and decimals of a foot.

4. A rectangular field is 5½ times as long as it is wide and contains 2¼ acres. What are the dimensions of the field?

5. What is the area of a roadway 60 ft. wide, of which the center line is a quarter circle with a radius of 500 ft.?

PROMOTION EXAMINATION, DRAFTSMAN, AQUEDUCT COMMISSION.

April 30, 1901.

1. Age, experience, education.

2. What is the most accurate method of plotting a survey and why?

3. How would you test the accuracy of a closed survey?

4. Draw a profile of a road 1 000 ft. long, and put thereon everything necessary to let a contract for grading.

5. Draw to scale a typical section of a masonry dam 30 ft. high, and an elevation of same showing bonding of courses on front face.

6. Draw a section of an earth dam 30 ft. high, illustrating the best construction.

7. Show a section of such a dam where sheet-piling is used in the foundation, showing the sheet piling.

8. Draw a section of a gate house on top of a dam, showing water inlets, and discharge pipes so arranged as to prevent leakage.

9. What are shade lines used for in drawings and where is the light supposed to come from?

10. Does friction in a pipe depend upon its diameter or its section; which?

11. To illustrate skill in drawing, sketch a pond in an area of 2 in. square, showing steep banks and some topography.

12. Extract the square root of a number.

13. Where is the center of pressure on a vertical dam 30 ft. high?

14. How much is the pressure against a rectangular dam, with a vertical face 27 ft. 9 in. by 10 ft. 7 in.?

STRUCTURAL STEEL DRAFTSMAN.

Salary, $1,200 to $1,800.

1. (*a*) What are the largest sections of I-beam, channel, and angle rolled? (*b*) What the lightest weight 20-in. and 18-in. beams?

2. Show by sketches the standard connection angle of a 15-in. and a 10-in. I-beam.

3. Show the conventional signs for rivets and field holes.

4. How close can $\frac{3}{4}$-in. rivets be driven (*a*) to each other, (*b*) to the edge of piece?

5. What points must be considered in designing floor construction and connections?

6. Same for columns?

7. (*a*) What is the least proportion of depth a plate girder should have to the span? (*b*) In general, how should stiffeners be spaced?

8. How would you secure transverse or wind bracing in a building where cast-iron columns are used?

9. Show by sketches a cast-iron column base for a 12-in. round column.

10. Show by sketches the usual connection of a cast-iron column for a 15-in. I-beam.

11. (*a*) What is the least bearing a beam should have on masonry? (*b*) How are such beams arranged?

12. What is the object of tie rods? Describe or show by sketch how they should be arranged for several beams of 20-in. span.

13. Describe and illustrate two methods of fire-proofing of beams and columns.

14. Design a stone footing of courses 2 ft. thick for a load, from a column of 250 tons, for ground which will take 4 tons per sq. ft. safely.

15. In designing a roof, what are the loads to be considered and how are these determined?

MATHEMATICS.

1. What is the area of metal of a round cast-iron column 1 in. thick and 11 in. outside diameter (three places of decimals)?

2. Extract the square root of 911 to four places of decimals.

3. A building 40 ft. by 108 ft. has a peaked roof with rise of 15 ft. How many square yards of roofing felt is required to cover it (neglecting lap)?

4. Reduce the following measurements to feet and four decimals of a foot: 17 ft. 11 in., 3.915 ft., 77.25 ft., 2 ft. $6\frac{3}{8}$ in., and 3 ft. $9\frac{13}{16}$ in.

5. Reduce the same measurements as in Question 4 to inches and three decimal places of an inch. Add them and reduce the result to feet, inches and fractions of an inch.

STRUCTURAL STEEL DRAFTSMAN.

1. What unit stresses do you consider proper for (*a*) medium steel in built girders; (*b*) rolled beams used as floor beams?

2. Same for cast iron (*a*) in tension; (*b*) in compression?

3. Same for rivets in (*a*) shear; (*b*) bearing?

4. Discuss briefly the comparative merits of wrought-steel and cast-iron columns for structural purposes.

5. What are the maximum moment and reactions of a girder 20 ft. long with a concentrated load in center of 15 000 lb. and a uniform load of 2 000 lb. per lin. ft. of girder?

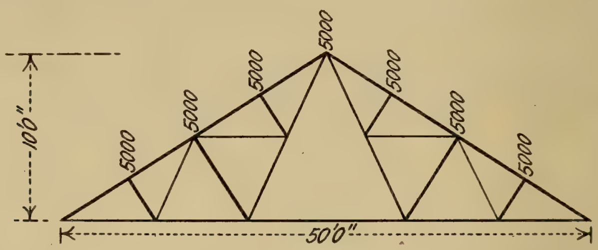
6. What is the required section of the lower chord of above girder when effective depth is 2 ft. and allowable tension per square inch as answered in Question 1?

7. Determine spacing of rivets in chords near end support, showing method of calculation when web is $\frac{3}{8}$ in. thick, and strain allowed for rivets as per answer to Question 3.

8. Make a free-hand sketch of stair string with ornamental railing, showing newel.

9. Make a free-hand sketch for detail of stair string connection at top and bottom of stairs.

10 and 11. Determine strains (graphically and analytically) of roof truss shown below.



12. Show by sketch or describe a method of vault lighting by use of prisms, and state under what conditions they can be used.

13. Make free-hand sketches of (*a*) a finial; (*b*) a gargoyle; (*c*) a corbel.

14. Show by sketch a (*a*) Doric, and (*b*) an Ionic column.

15. Make a free-hand sketch of a wrought-iron grille for a ticket-office window.

STRUCTURAL STEEL DRAFTSMAN.

1903.

1. In a casting, what is draft? How much is it proper to allow? What other points are to be observed in designing castings?

2. What is the safe and what the ultimate strength of a lap joint with 6 rivets staggered?

3. How would you get the shear at any point in a beam loaded at 3 points, and how would you obtain the maximum B. M.?

4. How would you space rivets in a column, with reference to each other and to the edge of the plate?

5. Sketch three types of bracing (wind).

6. How should stiffeners be designed at the end of a plate girder?

7. Make sketch for a steel (built up) column footing to transmit to masonry foundation a load of 200 tons.

8. Sketch standard connection angles for 24-, 15- and 8-in. I.

9 and 10. Given a roof truss with rise of $\frac{1}{3}$ span. Span is 50 ft. Trusses 8 ft. apart; total load over the whole surface 30 lb. per sq. ft. Design truss.

11. Give a sketch and description of cantilever construction for foundation and also for fourth tier.

12. Design a joint for a flange composed of 2-6″ by 6″ by $\frac{1}{2}$″ L's and 1-14″ by $\frac{1}{2}$ in. cover.

13. What advantage has an 18-in. I of 55 lb. per foot over a 15-in. I of equal weight? If 15-in. I will carry the load, what is the advantage in its use?

14. Make neat sketches for (*a*) cast-iron separator for 15-in. beam; (*b*) clevis; (*c*) sleeve nut; (*d*) turn buckle for $1\frac{1}{2}$-in. rod.

15. Sketch section of column composed of (*a*) plates and angles; (*b*) plates and channels; (*c*) 6 segment Phœnix column; (*d*) 2 channels and 1 I -beam; (*e*) Z-bars and plate.

STRUCTURAL STEEL DRAFTSMAN.

1. How is the strength of a rivet computed; also about what constants would you adopt for steel rivets in such a computation?

2. Would you adopt the same constants for field rivets as for shop driven, and what reasons can you give for your decision?

3. Is there any rule, and if so what, (*a*) for the minimum and maximum distances between rivets in riveted floor beams or columns; (*b*) for the minimum distance from the rivet hole to the edge of any piece?

4. How is the strength of a rod having a screw thread on it calculated, and in what case can the full strength of the rod be considered available?

5. Suppose a beam supported at its extremities to carry three or more loads; describe the operation of finding (*a*) the shear at any point; (*b*) the maximum moment.

6. Sketch carefully by cross-section, etc., (*a*) a bridge post made of four Z-bars and a plate; (*b*) show a bridge post made up of plates and angles.

7. State how you would compute the necessary number, spacing and dimensions of stiffeners at the end of a plate girder.

8. (*a*) What is the object of camber in a bridge truss? (*b*) State how you would provide the proper amount in any given case.

9. In a plate girder made up of a web, cover plates and angles, state how you would determine the economical lengths of the plates where several thicknesses are used in each flange.

10. State how you would compute the number of rivets required in any given length of the flanges of a plate girder.

11. In a through-truss bridge, how are the stresses in the diagonals between the chords transmitted to the masonry at the ends?

12. In making a working drawing for a casting, such as a bedplate or other design of somewhat complicated form, what must be done to insure sound castings, in so far as the draughtsman can aid in so doing?

13. What unit stresses would you assume as safe in the use of medium steel; (*a*) for a city bridge under very heavy traffic; (*b*) for a bridge for ordinary highway traffic; (*c*) for a roof truss?

14. What is the best way for attaching horizontal diagonals to the upper chords of a truss? Give sketch.

15. Give sketch of a well-proportioned eye-bar head and pin with relative dimensions.

STRUCTURAL STEEL DRAFTSMAN.

DEPARTMENT OF BRIDGES.

$1 800 and up. APRIL 25, 1905.

1. Show by sketch the standard sections of columns used in structural steel work.

2. Show two standard sections of trough floors.

3. Explain how an I-beam is designed for uniform load. Explanation of handbook table will receive proper consideration.

4. Define (*a*) moment of inertia, (*b*) radius of gyration, (*c*) section modulus.

5. Explain Gordon's formula and give the three applications of its use.

6. Design an eye-bar head for a 4-in. diameter pin and 6-in. width of bar; allow 50% excess of material in head.

7. State the various loads employed to get the stresses for (*a*) fixed highway bridges, (*b*) fixed railway bridges.

8 and 9. Make a neat drawing of a connection of the top chord of a Warren truss with a vertical post at the center of a chord member; the chord consists of two angles, 3″ by 3″ by $\frac{3}{8}$ in., one top plate, $\frac{3}{8}$″ by 16 in., two webs, $\frac{3}{8}$″ by 16 in., two angles, 3″ by 3″ by $\frac{3}{8}$ in., two flats, 3″ by $\frac{1}{2}$ in.; the post consists of two channels, 13.75 lb. per ft.

10. What would be the weight of the chord section per foot if 3 by 3 by $\frac{3}{8}$-in. angles are 7.2 lb. per ft. and 12 by 1-in plate, 10.8 lb. per ft.?

11. Make a sketch of the connection of a heavy floor beam to a post.

12. (*a*) Give the rules for rivet spacing. (*b*) What are the general notes on shop drawings in regard to rivet holes?

13. Make sketches for two styles of expansion bearings for a 100-ft. plate girder.

14. Arrange the following title in free-hand lettering or printing: Department of Bridges—Bridge over Harlem River at 145th Street. Scale $\frac{1}{8}$ in. = 1 ft.

MATHEMATICS.

1. Extract the square root of 1547.52086.

2. What is the weight of a round steel bar 4 in. diameter, 16 ft. 6 in. long, if the weight of steel is taken at 490 lb. per cu. ft.?

3. A certain contract for bridge work amounts to $230 800; if the masonry to 32%, the piling to 23%, the woodwork to 9%, and the balance is steelwork which costs $3\frac{1}{4}$ cents per lb., how many tons of steelwork were in the contract?

STRUCTURAL STEEL BRIDGE DRAFTSMAN.

Technical.

1. Make sketches showing at least five panels of the following styles of trusses, *viz.:* Whipple (single intersection); Warren, or triangular; and bow-string. Indicate in each by heavy lines the parts which are in compression when the truss is uniformly loaded.

2. Take the case of a five-panel Whipple truss, and show which members are affected by a load on the second panel from one end, and the kind of strain produced in each.

3. What is "shear" in a truss, and how is it determined at any point?

4. The strength of a column depends upon the area of the metal section, the diameter, and the length. For columns of similar construction, give in general, for changes in each of these, the ratio in which the strength of a column will be affected.

5. Give a sketch of what you would consider the best method of attaching rod sway-braces to iron trusses.

6. How would you compute the strength of a riveted joint?

7. Suppose an abutment 15 ft. high to be required for a bridge 50 ft. wide over a running stream. Give a sketch of the same in plan and section, with full dimensions, such as you would deem necessary.

8. Suppose the ground in this case to be unsound; give a sketch of a pile foundation, giving everything up to the stonework, with dimensions.

9. A pine bridge is to be built on a 45° skew for 20-ft. roadway, with the view at some later date of doubling the width of roadway. (*a*) How should trusses be arranged for final economy of construction? (*b*) How many halves of trusses must be independently calculated, and why?

10. In making a final inspection for acceptance of the metal superstructure of a new pin highway, state what points should receive attention.

11. In examining the condition of an old through pin bridge, state the important points of inspection as regards (*a*) floor connections; (*b*) counters; (*c*) what for double track? (*d*) what for four track?

12. What are proper unit strains to allow for medium steel in the following member of highway bridges: (*a*) Lateral bracing (tension); (*b*) rolled beams used as floor beams; (*c*) bottom chord-forged eye-bars; (*d*) bottom chord-built plates and shapes; (*e*) chord segments (compression)?

Extra Paper.

1. What, in your opinion, should distinguish (*a*) a good general drawing; (*b*) a good detail drawing; and (*c*) a good shop drawing?

2. What are least proper clearances to allow between (*a*) shoe inside of end-post; (*b*) pin-connected bridge; (*c*) 8-in. pin and pin-hole; (*d*) 2-in. pin for material connection and pin-hole?

3. Show by sketch the conventional signs for rivet-holes and rivets, including countersunk, flat-head, etc.

4. How shall a rivet be spaced (*a*) to another rivet; (*b*) to the leg of an angle; (*c*) why not closer?

5. What is the least proportion the depth of plate-girders should have to the span? (*b*) Same for rolled beams used as stringers?

6. What should be the actual size of punched rivet-holes for $\frac{7}{8}$-in. rivet? (*b*) What size is assumed in calculating net sections?

7. How close is it proper to space rivets in a diagonal line in a riveted tension member as compared with a transverse line?

8. Design and show by sketch a properly proportioned eye-bar head for a bar taking a strain of 250 000 lb. Allow unit stress of 12 500 lb. per sq. in.

9. Show graphically and compute analytically a pin required for panel point $L2$ where members and stresses are as follows:

$L1$ $L2$....2 eye-bars 260 000 lb.
$L2$ $U1$....2 eye-bars 335 000 lb. Diagonal at 45°.
$L2$ $L3$....4 eye-bars 450 000 lb.
$L2$ $U2$....Post with webs spaced 16 in., 220 000 lb.
Allowed bending 20 000 lb. per sq. in., bearing 12 000 lb.

10. Assume reasonable main sections and make calculations necessary for detail connection of stringer to floor-beam and hanger at end to pin for a floor-beam 16 ft. long. Two stringers connect on each side spaced 7-ft. centers, and transmitting 930 000 lb. each.

11. Make complete shop drawing of above floor-beam, giving rivet spacing and necessary dimensions; state reasonable unit stresses of main section and assumption for details.

12. Make neat tracing of above drawing.

13. Make a neat drawing of a nest of ten rollers, 3 ft. long, $4\frac{1}{2}$ in. diameter, with all necessary details, including bottom bearing-plates.

14. Make neat, but not necessarily accurate, drawing of a stiff portal bracing with name-plate for a large through bridge span. Let this be ornamental.

15. Show your skill in lettering by arranging and showing style of letters for the following caption:

Elevation, Proposed East River Bridge, Number 4, Department of Bridges, City of New York, May 17, 1901.

Mathematics.

1. Extract the square root of 9361.429 to four places of decimals.

2. Multiply .01629 by 47.3 and divide the product by 906.42. Give answer five places in decimals.

3. By logarithms multiply 43.972 by .0361 and divide the product by .0016.

4. A cast-iron column is 8 in. outside diameter, 1 in. thickness of metal. What diameter of column with metal $\frac{3}{4}$ in. thick will give the same area of cross-section of metal?

5. The panel length of a bridge is 21 ft. 0 in., the length of diagonal 35 ft. What is the height of post and the sine of the angle of inclination from the vertical?

MANUAL OF EXAMINATIONS

FOR

ENGINEERING POSITIONS

IN THE

SERVICE OF THE CITY OF NEW YORK

DRAFTSMAN

AND

DRAFTSMAN'S HELPER

TYPICAL QUESTIONS AND ANSWERS

TYPICAL QUESTIONS AND ANSWERS.

DRAFTSMAN'S HELPER.

1. What do you understand to be the duties of junior assistant draftsman?

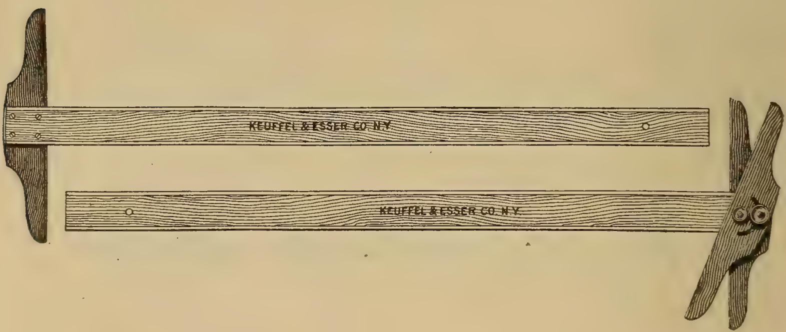
He is required to
(*a*) Make tracings.
(*b*) Make blueprints.
(*c*) Put titles and other lettering on tracings.
(*d*) To index drawings and other records.
(*e*) To assist in simple calculations.
(*f*) To ink in drawings made by senior draftsmen.
(*g*) To make himself generally useful around the office.

2. Mention the principal instruments used by a draftsman.

Refer to Pages 27, 28 and 29.

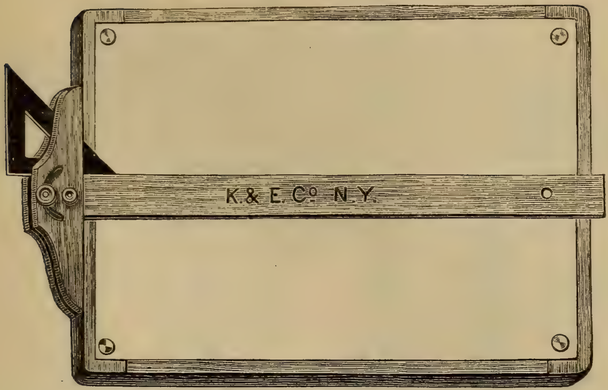
3. What is a "T" square and how is it used?

A "T" square is a straight edge, either of wood or steel, with a perpendicular piece fastened to it at one end.

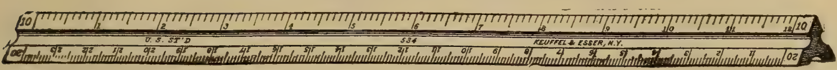


The "T" square is used to draw straight lines on the board, parallel to each other and perpendicular to the sides of the board. The head is placed firmly against the left-hand edge of the board, the upper edge of the blade is placed at the point through which it is desired to draw the line; the latter which is then drawn by passing the pencil or pen along the edge of the blade.

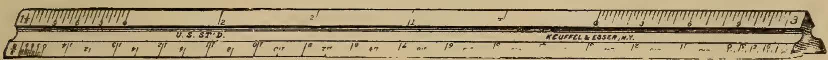
DRAFTSMAN'S INSTRUMENTS.



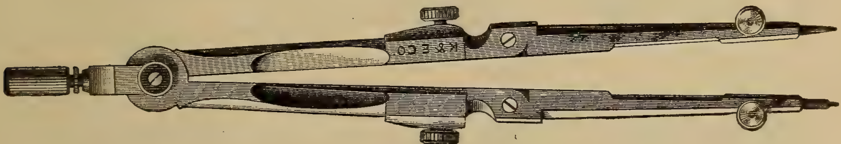
Drawing Board, T-Square and Triangles.



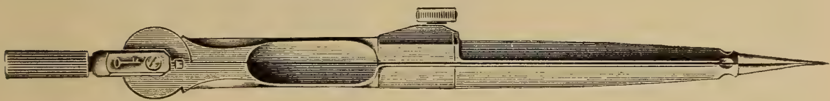
Engineer's Scale.



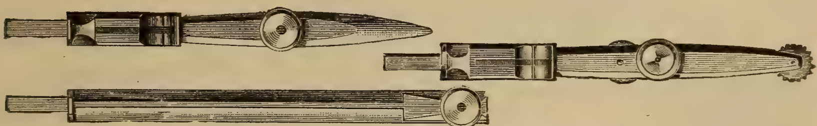
Architect's Scale.



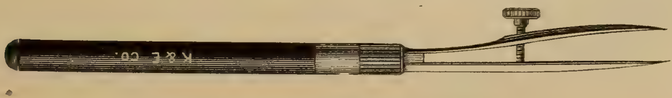
Pencil Compass.



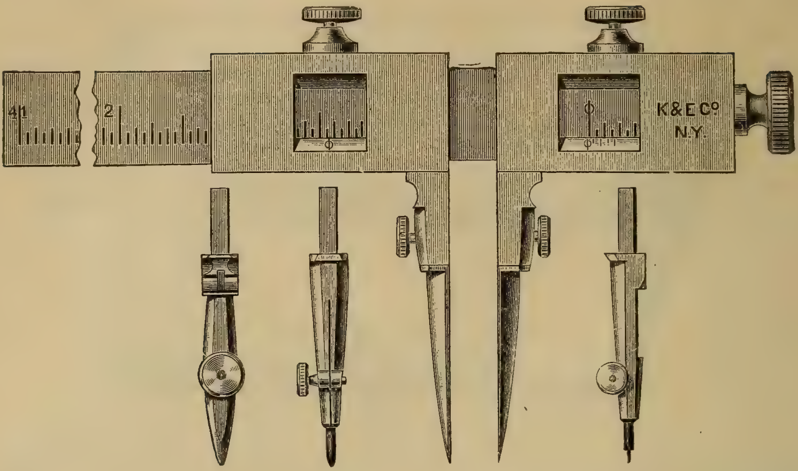
Dividers.



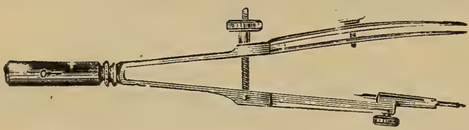
Dotting Pen, Compass Lengthener, Compass Pen.



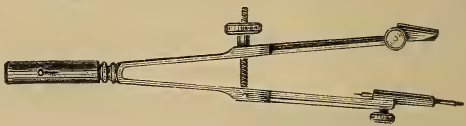
Drawing Pen, or Straight Line Pen.



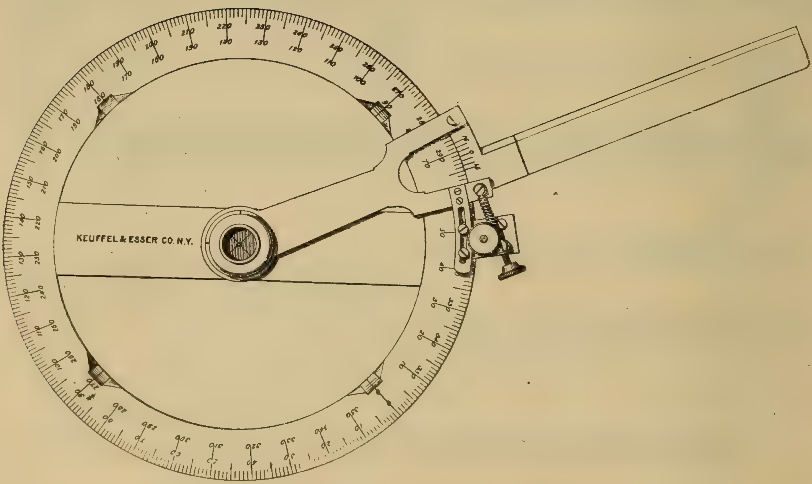
Beam Compass.



Bow Pen.

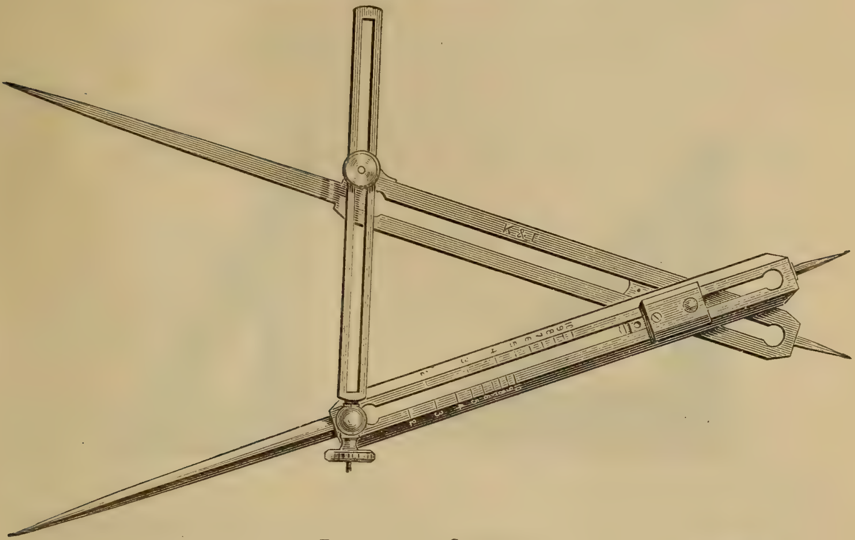


Bow Pencil.

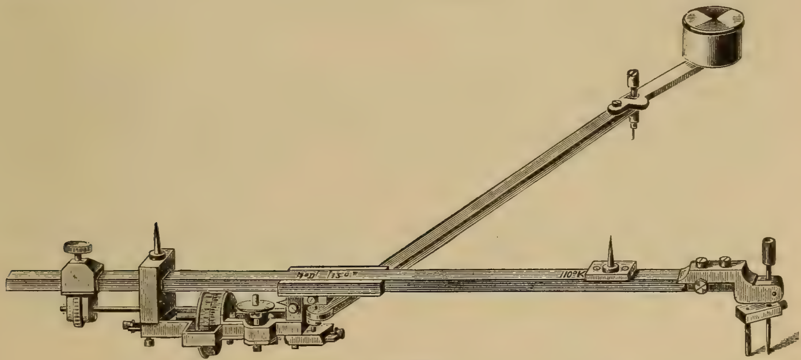


Protractor, with Arm, Vernier and Tangent Screw.

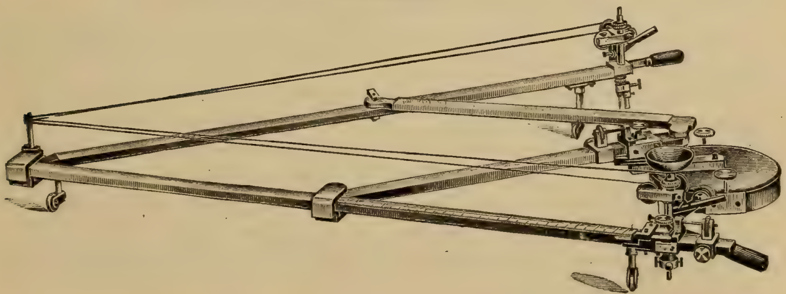
DRAFTSMAN'S INSTRUMENTS.



PROPORTIONAL DIVIDERS.



PLANIMETER.



PANTOGRAPH.

4. Describe the two "triangles" most used and how vertical lines can be drawn with them.

The two triangles most used are 45° and 60°.

A 45° triangle is a drawing instrument of celluloid, hard rubber, &c., having one angle of 90° and two of 45°. A 60° triangle has a 90° angle, a 60° and a 30°.

A vertical line can be drawn on the paper by placing the "T" square into position, and holding one edge of the 90° angle of the triangle against the edge of the blade; the vertical line is then drawn by passing the pencil along the other side of the 90° angle.

5. How are original drawings reproduced so that various copies may be sent to contractors or used on construction?

By making blue-prints or black-prints from the original tracing.

6. How is the blue print made from a tracing?

In a room free from direct sunlight the tracing is placed in a blue-print frame, the face of the drawing against the glass; then a piece of blue-print paper is spread over this, with the prepared side towards the tracing; the back of the printing frame is then replaced and held tightly in position by clamps. Expose the printing frame to the sunlight. After the print has been sufficiently exposed (the time depending upon the kind of paper used and the intensity of the sunlight), the frame is taken to the room, the blue-print paper removed and quickly placed in a bath of water, after which the print is hung up to dry.

7. (*a*) How do the sides of the tracing cloth differ? (*b*) What is the advantage of using each side as compared with the other?

(*a*) One side is smooth and glossy, the other is dull.

(*b*) It is easier to make pencil marks and sketches on the dull side. The ink also takes better on this side.

The advantage of using the glossy side is that it is easier to erase ink marks than on the other, and the erasure does not show as badly.

8. After having to erase ink on tracing cloth, how can you prevent the new work from running?

By rubbing a piece of soapstone over the portion where the erasure has been made. If no soapstone is at hand, any hard, rounded substance may be employed.

9. What scale is used for (*a*) general drawings, (*b*) detail drawings, for school buildings?

(*a*) Either $\frac{1}{4}'' = 1'$, or if this makes the drawing too large for the sheet use $\frac{1}{8}'' = 1'$.

(*b*) $\frac{1}{2}'' = 1'$, $1'' = 1'$, $1\frac{1}{2}'' = 1'$, $3'' = 1'$, or full size.

10. Name all the drawings necessary to show the character of construction of a steel frame building.

(*a*) Front elevation, rear elevation, and side elevations, if any.
(*b*) Cellar plan.
(*c*) Upper floor plans.
(*d*) Cross-section.
(*e*) Longitudinal section.
(*f*) Girder plans.
(*g*) Column schedule.

11. What colors are used to indicate the following materials: (*a*) iron; (*b*) wood; (*c*) plaster; (*d*) concrete; (*e*) granite; (*f*) fire brick; (*g*) bronze and copper; (*h*) fire proofing?

(*a*) bluish gray.
(*b*) yellow.
(*c*) red.
(*d*) blue.
(*e*) blue..
(*f*) red.
(*g*) green.
(*h*) red.

12. How are water colors mixed and applied to secure uniform tints and neat appearance?

To prepare a color for use, pour a small amount of water into a clean porcelain dish, hold the cake of paint at the side of the dish, moisten the brush and rub it over the cake and apply to the dish until the mixture gives the required shade.

To apply the color, commence at the top of the sheet and draw the brush quickly across from left to right; again starting at the left apply another band of color, and so on until the portion to be colored is completed. Care must be taken not to allow the lower edge to dry before the succeeding band of color is applied; otherwise the tint will not have a uniform appearance.

13. What materials would the following colors indicate on drawings: (*a*) blue-gray; (*b*) red; (*c*) blue; (*d*) slate; (*e*) yellow?

(*a*) steel or iron.
(*b*) brick work, or any material manufactured from clay.
(*c*) masonry.
(*d*) slate.
(*e*) wood.

14. (*a*) Why should ink on the outside of a right line ruling pen be wiped away?

(*b*) What is the best way of getting ink on a right line ruling pen?

(*a*) To avoid making a blot.
(*b*) By using the quill attached to the cork of the ink bottle.

15. How are contemplated alterations of an existing building shown on plans?

The usual method is to show all proposed work by heavy lines, and the old or existing work by light or broken lines.

When colors are used it is customary to show new work in red, the old work being left uncolored.

16. Explain the following terms used in carpentry specifications: (*a*) centers (for mason); (*b*) furring; (*c*) trim; (*d*) wedging.

(*a*) Centers are wooden forms used to support the arches or openings in walls during construction.

(*b*) Furring consists of light strips, to which the laths and plastering are fastened.

(*c*) The trim in rooms consists of base-boards, and finishing boards around windows, doors and other openings.

(*d*) Wedge-shaped pieces of wood or iron used as shim-plates to bring columns or girders into true position.

17. Explain the following terms used in masonry specifications: (*a*) Flemish bond; (*b*) stone templet; (*c*) wash (of sills); (*d*) drip (of cornice).

(*a*) Flemish bond consists of alternate headers and stretchers in every course, every header being immediately over the center of a stretcher in the course below.

(*b*) A stone templet is a stone built into a wall to take the bearing of a beam supported by the wall.

(*c*) The wash of sills is the slope given to the upper surface in order to shed water.

(*d*) The "drip" is that portion of a cornice which has a projection beyond the other parts for throwing off water which would otherwise trickle down on parts beneath.

18. (*a*) What is a column; (*b*) a pilaster?

(*a*) A column is a member used in construction, designed to withstand compressive stresses.

(*b*) A pilaster is a rectangular post resting against a wall, and projecting from the wall about a fourth or a sixth part of its breadth.

19. (*a*) What are shop rivets? (*b*) What do open holes show on shop drawings?

(*a*) Rivets driven in the shop.

(*b*) They show position of field rivets or bolts.

20. (*a*) How many square chains (of 66 ft. per chain) are there in an acre? (*b*) How many square feet are there in an acre?

(*a*) 10 square chains.

(*b*) 43 560 sq. ft.

TOPOGRAPHICAL DRAFTSMAN.

21. What are the duties of a topographical draftsman? State all the kinds of maps you would be called upon to draw.

A topographical draftsman is required to examine, reduce and plot notes of surveys.

To compute and balance traverses.

To make drawings, tracings and blue-prints, neatly and rapidly.

To reduce or enlarge drawings.

He should be familiar with the use of logarithms and the trigonometric functions.

He may be called upon to prepare —

Topographical maps,
Street-opening maps,
Damage maps,
Benefit maps,
Rule maps,
Drainage maps,
Layout maps for dams, sewers, highways, bridges and other work.

22. What is topography?

Topography is the complete determination and representation of any portion of the surface of the earth, showing the relative heights and positions of all features, both natural and artificial.

23. What is a topographical map?

A topographical map is a drawing of a portion of the earth's surface showing the relative position of all points, both natural and artificial, and also their relative elevations. All features are represented by conventional signs.

24. What are the objects of a topographical drawing, especially of a portion of new wards of the city?

The objects are to obtain data for laying out new streets, drainage systems, water-sheds, sites for dams, parks, railroads, calculating earthwork, etc.

25. (*a*) What would a good topographical map show for a sewer outlay in a new portion of the city? (*b*) What should such a map show for a park outlay?

(*a*) 1. Correct plan and character of all the present and proposed streets in the district.
2. All buildings in the district.
3. Complete contour system.
4. Profile.
5. Location and character of all forests, meadows, swamps.
6. Water courses.
7. All existing sewers and drains.

(*b*) 1. Same as above.
2. Same as above.
3. Same as above referred to system of squares.
4. Location and character of trees, forests, shrubbery, water courses, surface rock, character of soil, drainage, etc.

26. (*a*) State all the information you could obtain from a topographical map. (*b*) State all the uses such a map could be put to.

(*a*) Location and names of streets and roads, location of water courses, lakes, seas, etc., location of houses, contours, elevations on street lines.

(*b*) 1. To lay out new roads, railroads, aqueducts, dams, etc. ("paper location").
2. To draw profiles and cross-sections.
3. To calculate amount of excavation in a hill, or fill in a valley.
4. To calculate contents of reservoirs, or storage area.
5. To find area of any desired portions for condemnation or damage work.

27. For the purpose of making such a map what notes are furnished and which require the most accuracy?

a. Notes or primary and secondary traverses to which all the work is referred.

b. Notes for the location of all topographic features referred to the traverse lines.

c. Notes for profiles and cross-sections of roads.

d. Notes showing elevations of a sufficient number of governing points by means of which contours are plotted.

The traverse work requires the greatest accuracy.

28. What are contour lines? How far apart are they on city maps? Do contours ever cross each other? Do they ever touch each other?

A contour is a continuous line passing through points on the surface of the earth, all of which are at the same elevation above or below a given datum.

In the city the contours below elevation + 50 are usually given 2 ft. apart vertically; above + 50 they are 5 ft. apart.

Contour lines cross each other on a steep bluff which slopes forward; they touch each other on a vertical bluff.

29. What are hachures? How are they drawn? What does the increase in thickness or the increase in space between hachures indicate?

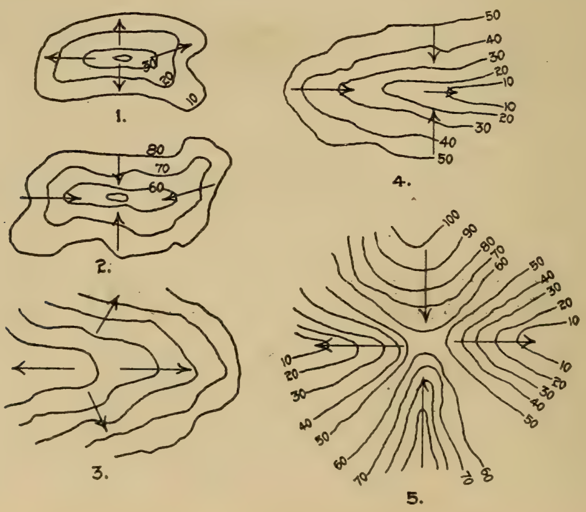
Hachures are lines drawn between adjacent contour lines. They are drawn normal to same and the hachures between any pair of contour lines break joints with those above and below. Short heavy lines close together represent steep slopes, thin lines spaced further apart indicate gentle slopes.

30. What is the horizontal system of topography? Explain upon what theory hills, valleys, etc., are represented in this system.

What is the vertical system?

In the horizontal system of topography the relative elevation of points on the surface are represented by means of contour lines.

The many varieties of contour lines are derived from five simple cases:



1. Sloping down on all sides, *i. e.,* a hill.

2. Sloping up on all sides, *i. e.,* a hollow.

3. Sloping down on three sides and up on one, *i. e.,* a shoulder or promontory, the end of a ridge or water-shed line.

4. Sloping up on three sides and down on one, *i. e.,* a valley or thalweg.

5. Sloping up on two sides and down on two, alternately, *i. e.,* a "pas" or "col," or "saddle."

(The arrows show direction of flow.)

In the vertical system of topography, slopes are shown by shade from vertical light; steep slopes are shaded very heavy and horizontal surfaces indicated white. Intermediate slopes are shown by a proper degree of shade between white and black. This system is rapid and effective, but is not very precise, unless used in combination with contour lines.

31. How do you represent the slopes of hills and valleys by contours? What is a scale of shade?

The contours are run through points of equal elevation and the elevations marked on them to indicate the direction of the slope; the nearer the contours approach each other the steeper the slope.

(See also Q. 30.)

In a scale of shade heavy short lines represent steep slopes, thin long lines, gentle slopes. In the German method a scale of nine different grades is used, representing slopes from 0° to 45°, the first grade being white and the last black; for intermediate slopes the following proportion of white to black is used:

$$\frac{\text{white}}{\text{black}} = \frac{45° - \text{angle of slope}}{\text{angle of slope}}.$$

Steeper slopes are represented by short heavy lines, parallel to the contour lines.

Many other arbitrary scales of shade are employed.

32. What do you understand by pen topography?

In pen topography, as distinguished from color topography, the topographical features are shown by conventional signs drawn by the pen.

33. How are level notes shown on a map, and what is such a map called?

Level notes are usually shown on a map by means of contour lines; the points at which elevations have been taken are also shown on the map.

Such a map is called a "contour" map.

34. Name the conventional colors for different features, natural and artificial?

Woods—yellow.
Grass-land—green.
Cultivated land—brown.
Gardens—small patches of green and brown.
Uncultivated land—marbled green and light brown.
Brush—marbled green and yellow.
Sand—light brown.
Lakes and rivers—light blue.
Seas—dark blue.
Marshes—blue, with spots of green.
Roads—brown.
Hills—greenish brown.

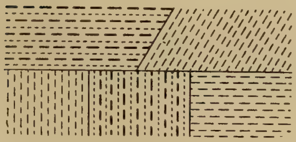
35. Give all the conventional signs you know of.

Some signs are given below. See Reinhardt's "Technic," p. 35, for more complete list of conventions.

Orchard.

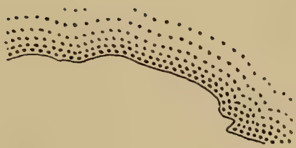
Grass.

Cultivated land.

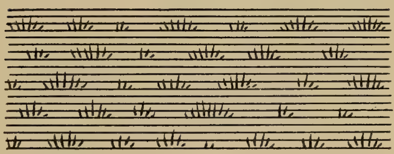


Sand.

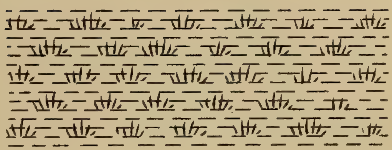
Gravel.



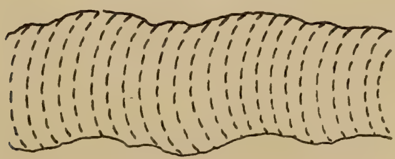
Salt-water marsh.



Fresh-water marsh.



Glacier.

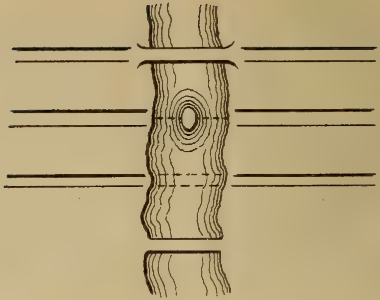


Bridge.

Ferry.

Ford.

Dam.



State line.

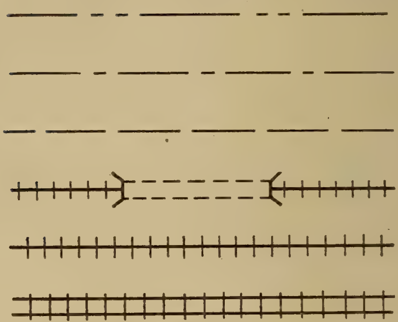
County line.

Township line.

Railroad tunnel.

Single-track railroad.

Double-track railroad.



36. How do you apply colors on a topographical map?

First stretch the paper on a drawing-board by wetting the former thoroughly with a sponge and gluing the edges to the board. When the paper has become dry it will be smooth and tight, and the application of colors will not cause it to swell or blister.

Mix the colors in porcelain dishes diluted to the proper tint, they must not be mixed thick.

To apply the color use a camel's hair brush, keep it moderately full. Incline the board towards you, begin at the upper part of the drawing and continue downward, never letting the lower edge of the color dry, and preferably from left to right across the board.

When colors are applied to a tracing they are painted on the back of the cloth so as not to blur or confuse the drawing. In order not to wrinkle the tracing the colors should be applied quickly and then blotted by means of ordinary blotting paper; before the colors have dried completely the tracing should be rolled up on a round stick and held thus with rubber bands until completely dry; this will cause the paper to remain smooth.

37. How would you lay out a map on paper with regard to cardinal points?

Having the map placed before you, north must come towards the top of the drawing, south towards the bottom, east towards the right and west towards the left.

38. What is the most accurate way of plotting a survey, and give your reason for preferring it?

The most accurate method is by "co-ordinates," that is, calculating the co-ordinates of all stations with respect to a pair of rectangular co-ordinates, plotting these co-ordinates and joining the points thus located.

In this method a point which is not plotted correctly will not affect the position of other points. Errors are thus confined to individual points and are not cumulative.

39. Assuming that you had to plot a course 1 080 ft. long N. 18° 40′ W. Describe two ways of doing it, one of which must be accurate, and state why it is so.

a. By means of scale and protractor. First draw the meridian lines (N. and S. and E. and W.) and by means of protractor lay off the angle of 18° 40′ to the left of north line, draw the course and measure to scale 1 080 ft. along same.

b. By means of latitudes and departures. Calculate the latitude and departure of course 1 080 ft. long bearing N. 18° 40′ W. Assume the intersection of the meridians as the beginning of the course. Lay off to scale the computed latitude to the north from the beginning and mark the point; at this point lay off to same scale the departure to the west and mark the point. Join this last point with the point of beginning, giving the required course.

The latitude and departure method is accurate because the positions on the drawing of the beginning and end of the course are determined with mathematical accuracy, and errors in plotting are minimized.

40. Describe the method of plotting the course of a survey by chords.

This is done by means of a table of chords which gives the lengths of the chords of arcs, for every degree and minute from 0° to 90°, calculated for a radius of unity.

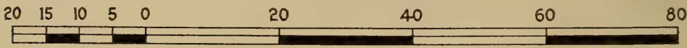
To lay off the course, draw meridian (N. and S.). With any point (as the beginning of the course) as center and a unit radius draw arc. Take out of table, length of chord for given bearing. With this as radius to the same scale, and the intersection of first arc and meridian as center, draw second arc. The intersection of the two arcs will be a second point on the course. Join this with point of beginning and lay off length to scale of drawing.

41. How would you draw a tangent to a circle from a point on the circumference?

At the given point draw a line perpendicular to the radius passing through it. This will be the required tangent.

42. Show several ways of expressing the scale for a map.

a. Scale, 1″ = 20′.
b. Scale, 20 ft. to the inch.
c. Scale, $\frac{1}{240}$.
d.



43. What is meant by a profile and show one drawn to scale, showing ten stations in broken country; show everything in detail?

A profile is a vertical section along a survey line usually drawn to a distorted scale so as to emphasize changes in elevation. The elevations of all breaks in the slope are given, as also the elevations at regular stations.

For profile drawn to scale see Question No. 46.

44. State all the data that could be obtained from a complete profile of any street in New York City.

a. Elevations of all points on center line.
b. Of all points on the curbs.
c. Of all points in the gutters.
d. All streets intersecting the given street.
e. Correct length and grade of street.

45. (*a*) To what datum are elevations in New York City referred? (*b*) Are elevations of any other part of the street given on the profile besides the center line?

(*a*) Elevations in New York City are referred to Mean High Water. There is no uniform datum for all departments.

(*b*) The elevations of both curb lines are usually given as well as those of the center line, and sometimes the house lines.

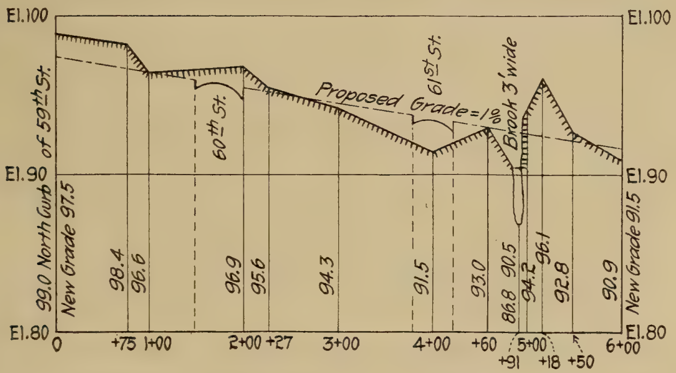
46. Show a page of your profile level notes for a distance of 600 ft. with numerous breaks in the surface and several set-ups. Reduce the notes, draw profile and grade line.

Profile along Center Line of Proposed Street.

July 16, 1892.

Party—J. B.—L. K.—R. S.

Sta.	B. S.	H. I.	F. S.	Elev.	Remarks.
B. M.	3.725	103.725		100.0	Water table N. W cor. 10th Ave. and 59th St.
0 + 0			4.7	99.0	North curb of 59th St.
0 + 75			5.3	98.4	
1 + 0			7.1	96.6	
2 + 0			6.8	96.9	
2 + 27			8.1	95.6	
3 + 0			9.4	94.3	
T. P.	4.219	97.731	10.213	93.512	
4 + 0			6.2	91.5	
4 + 60			4.7	93.0	
4 + 91			10.9	86.8	Bottom of brook three feet wide.
4 + 91			7.2	90.5	Surface of water.
5 + 0			3.5	94.2	
T. P.	7.369	102.312	2.788	94.943	
5 + 18			6.2	96.1	
5 + 50			9.5	92.8	
6 + 0			11.4	90.9	
B. M. 10			8.792	93.520	See P. 100. El. 93.525.



Profile on Center Line of Proposed Street.

47. What is meant by a traverse? A logarithm? A right-of-way map? What is a well-conditioned angle?

A traverse is a closed survey of any tract of land giving the lengths of all the courses and the angles between adjacent ones.

A logarithm of any number is the exponent of the power to which an assumed base must be raised to give that number. Ten is the base of the common system.

A right-of-way map of a railroad is one showing the land secured by the road for the purpose of operation.

A well-conditioned angle is one whose logarithmic functions do not vary rapidly; a slight error in measurement of same would have a small effect upon the calculation.

48. What are latitudes and departures and how do you find them accurately?

If B = bearing of a course and L, its length.
Latitude = $L \times$ cos. B.
Departure = $L \times$ sin. B.
They are obtained accurately by means of logarithmic tables.

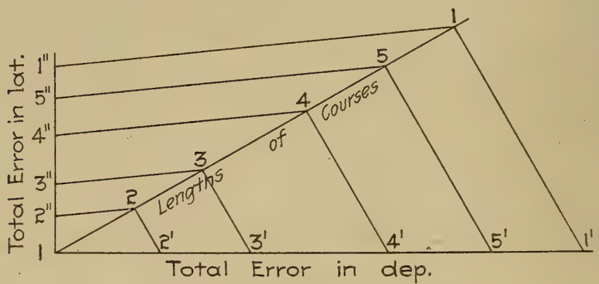
49. What is meant by balancing a survey?

"Balancing" a survey is the proportioning of the errors of latitude and departure among the courses, so that the sum of the northings equals the sum of the southings, and the sum of the eastings equals that of the westings.

The rule usually employed is "The correction for any course is to total error as the length of that course is to total perimeter.

50. When a survey does not balance what do you do both in computation and in drawing?

To find corrections mathematically, see Question 49.



To find the corrections graphically lay off from some point the total error of latitude and of departure at right angles to each other, to any convenient scale. From this point lay off a line representing the perimeter of the traverse to convenient scale, giving lengths of the courses continuously, as shown in diagram. 5′-1′ = departure correction for course 5-1, etc.

These corrections should be applied to the computed latitudes and departures to make the survey balance.

51. (*a*) What are the causes of error in angular measurements? (*b*) In linear measurements?

(*a*) 1. Slipping and shifting of instrument parts.
2. Reading the verniers incorrectly.
3. Errors in bisection.
4. Poor and indistinct sights.
5. Not setting up instrument directly over point.
6. Horizontal axis not in adjustment.
7. Line of collimation out of adjustment (in measuring deflection angles by plunging).
8. Plate not horizontal.

(*b*) Errors in linear measurements.
1. Tape not standardized.
2. Tape not held correctly over points.
3. Tape not held truly horizontal.
4. Expansion or contraction of tape due to changes in temperature not allowed for.
5. Reading tape incorrectly.
6. Not applying proper tension.
7. Kinks in tape and obstructions to measurement.

52. How would you examine the notes of an extensive closed survey to see if it is within the limits of accuracy? State where in such a survey you would look for the errors to have been made having regard to lines, location of stations, etc.

Add up the interior angles of the survey. Their sum should equal $180° \times$ number of sides, minus 360°. If the angles check closely, distribute the error, compute the latitudes and departures and the "error of closure" which =

$$\sqrt{(\text{Error in Lat.})^2 + (\text{Error in Dep.})^2}.$$

If the angles do not "close" or the "error of closure" is too great, examine notes carefully to detect errors in the record. If compass bearings have been taken compare them with the computed bearings.

If no error can be found in the notes the computation should be reviewed before any field work is repeated.

53. How would you supply a missing course? (In a traverse.)

Compute the latitudes and departures of the courses, take the sum of the north and the sum of the south latitudes and find the difference of the sums. Do the same with E. and W. departures.

If L = length of missing side

lat. = Diff. in latitudes,

dep. = " departures.

Then $L = \sqrt{(\text{lat.})^2 + (\text{dep.})^2}$.

If B = bearing of missing course,

$$\tan. B = \frac{\text{lat.}}{\text{dep.}}.$$

54. What is a traverse table and how is it used?

A traverse table is one giving the latitude and departure of courses 1′, 2′, 3′, 4′, 5′, 6′, 7′, 8′ and 9′ long, for all angles between 0° and 90°. Very good tables give the latitudes and departures for distances from 1′ to 100′ long, and for each minute of arc.

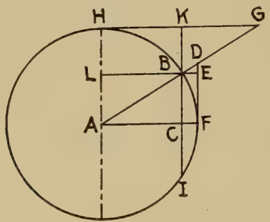
To get the departure of a course 5 876 ft. long for angle of 39°-17′. Look up departures for 39° 17′ and take 1 000 times the departure of 5′, 100 times the departure of 8′, 10 times the departure of 7′, 1 times the departure of 6′.

The sum of these products is the required departure.

55. What form of notes would you require to enable you to plot an irregular shore line of a lake or river?

A meander line with perpendicular offsets from the same to enough points on the shore line to properly locate it for the purpose of the survey.

56. In a circle of one inch radius show by letters the trigonometric functions, giving position and lengths.



Let A = angle $B\ A\ C$

Radius $A\ F$ = 1 in.

Then $\sin A = B\ C$

$\cos A = A\ C$

$$
\begin{aligned}
\tan A &= D\,F \\
\cot A &= H\,G \\
\sec A &= A\,D \\
\operatorname{cosec} A &= A\,G \\
\operatorname{versin} A &= C\,F = B\,E \\
\operatorname{coversin} A &= B\,K = H\,L \\
\operatorname{exsec} A &= B\,D \\
\operatorname{coexsec} A &= B\,G
\end{aligned}
$$

57. Are the sines and cosines always plus? If not, how are they accounted for in calculations? Give the mathematical relations between the sin., cos., tan., cot., sec. and cosec. of an angle.

Sines are + in the first and second quadrants and — in the third and fourth.

Cosines are + in the first and 4th quadrants and — in the second and third.

Logarithms used are always +, the algebraic sign of the answer to any problem is obtained by the regular rules of algebra and the signs of the factors are disregarded in looking up the logarithms.

58. Do the signs remain the same for an angle over 90° for all functions as for one under 90°? If not, why not?

The signs of functions of an angle over 90° are not all the same as those for an angle under 90°, because the signs of the functions depend upon their positions with respect to the axes of reference, the axes to the left and below being considered negative, and as the angle increases above 90° the functions change their signs accordingly.

59. Describe how the area of a piece of land is determined by (*a*) the use of the planimeter, (*b*) by double meridian distances. (*c*) What other methods are used?

(*a*) The planimeter is first set so as to read square inches; it is then placed on the plat, split up into suitable sections, the prick point pressed into the paper wherever convenient, and the pointer passed around the perimeter of the section until it returns to the starting point. The index then shows the number of square inches included in the section, and so on for each section of the plot. The total, multiplied by the square of the scale of the drawing, gives the area.

(*b*) Twice the area of the plot is equal to the algebraic sum of the products obtained by multiplying the latitude of each course by its double meridian distance.

Values of the Six Principal Functions of any Angle x, in Terms of one another.

	sin. x.	cos. x.	tan. x.	cot. x.	sec. x.	cosec. x.
sin. x........................	1	$\sqrt{1-\cos.^2 x}$	$\frac{\tan. x}{\sqrt{1+\tan.^2 x}}$	$\frac{1}{\sqrt{1+\cot.^2 x}}$	$\frac{\sqrt{\sec.^2 x-1}}{\sec. x}$	$\frac{1}{\text{cosec. } x}$
cos. x........................	$\sqrt{1-\sin.^2 x}$	1	$\frac{1}{\sqrt{1+\tan.^2 x}}$	$\frac{\cot. x}{\sqrt{1+\cot.^2 x}}$	$\frac{1}{\sec. x}$	$\frac{\sqrt{\text{cosec.}^2-1}}{\text{cosec. } x}$
tan. x........................	$\frac{\sin.}{\sqrt{1-\sin.^2 x}}$	$\frac{\sqrt{1-\cos.^2 x}}{\cos. x}$	1	$\frac{1}{\cot. x}$	$\sqrt{\sec.^2-1}$	$\frac{1}{\sqrt{\text{cosec.}^2 x-1}}$
cot. x........................	$\frac{\sqrt{1-\sin.^2 x}}{\sin.}$	$\frac{\cos.}{\sqrt{1-\cos.^2 x}}$	$\frac{1}{\tan. x.}$	1	$\frac{1}{\sqrt{\sec.^2 x-1}}$	$\sqrt{\text{cosec.}^2 x-1}$
sec. x........................	$\frac{1}{\sqrt{1-\sin^2 x}}$	$\frac{1}{\cos. x}$	$\sqrt{1+\tan.^2 x}$	$\frac{\sqrt{1+\cot.^2 x}}{\cot. x}$	1	$\frac{\text{cosec. } x}{\sqrt{\text{cosec}^2 x-1}}$
cosec. x........................	$\frac{1}{\sin. x}$	$\frac{1}{\sqrt{1-\cos.^2 x}}$	$\frac{\sqrt{1+\tan.^2 x}}{\tan. x}$	$\sqrt{1+\cot.^2 x}$	$\frac{\sec. x}{\sqrt{\sec.^2 x-1}}$	1

Note.—Complete relations given although not required by the question.

(*c*) 1. By dividing the plot into triangles, trapezoids, etc., scaling dimensions and calculating areas from these approximate dimensions.

2. By plotting on cardboard of uniform thickness, cutting out along the perimeter and comparing weight of plot with weight of known area.

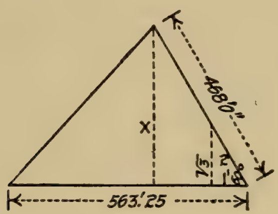
3. By plotting the work on cross-section paper and counting the squares included within the perimeter, the area may be approximately determined.

60. In computing the parts of a triangle how many different cases may arise? To which one may two correct answers be given and under what conditions?

1. Two sides and the included angle.
2. Two angles and the included side.
3. Three sides and no angles.
4. Two sides and the angle opposite one of them.

There may be two correct solutions in the fourth case when the given angle is less than 90°, and the side opposite it divided by the adjacent side is greater than the natural sine of the angle.

61. The base of a triangle is 563.25 feet long and one of the other sides is 468 ft. The included angle is equal to 60°. What is the area of the triangle?



From similar triangles we have

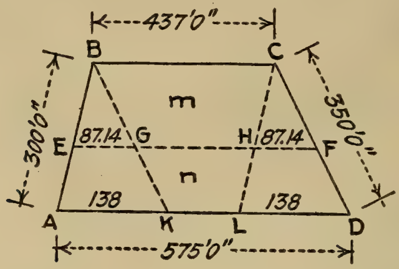
$$\frac{x}{\sqrt{3}} = \frac{468}{2} = 234$$

$$\begin{aligned} \text{whence } x &= 234 \text{ times } \sqrt{3} \\ &= 234 \text{ times } 1.7321 \\ &= 435.31 \text{ feet} \end{aligned}$$

and

$$\begin{aligned} \text{area} &= 435.31 \text{ times } 563.25 \text{ divided by } 2. \\ &= 122{,}594.18 \text{ sq. ft. Ans.} \end{aligned}$$

62. A trapezoidal piece of ground is to be divided into two parts in the ratio of 2 to 3 by a line parallel to the parallel sides, the larger part to be adjacent to the smaller parallel side. The parallel sides are respectively, 575 ft. and 437 ft. long, the other sides are 300 ft. and 350 ft. long. Find the distance to the dividing line from the longest parallel side on each of the other sides.



Draw $E\,F$ parallel to $A\,D$, $B\,K$ to $C\,D$, and $C\,L$ to $A\,B$.
$L\,D = A\,K = 575 - 437 = 138$ ft.

Required to make $\dfrac{B\,E\,F\,C}{A\,E\,F\,D} = \dfrac{3}{2} = \dfrac{m}{n}$.

$$E\,F = \sqrt{\left(\frac{m \times \overline{A\,D}^2 + n \times \overline{B\,C}^2}{m+n}\right)}$$

NOTE.—See Gillespie's "Surveying."

$$E\,F = \sqrt{\frac{3\,(575)^2 + 2\,(437)^2}{3+2}} = 524.14 \text{ ft.}$$

Then $H\,F = E\,G = E\,F - B\,C = 87.14$ ft.
From similar triangles we then have

$$\frac{C\,F}{87.14} = \frac{350}{138}, \text{ or } C\,F = 221.0 \text{ ft.}$$

also $$\frac{B\,E}{87.14} = \frac{300}{138}, \text{ or } B\,E = 189.44 \text{ ft.}$$

Hence

$$F\,D = 350 - 221.0 = 129.0 \text{ ft. Ans.}$$
$$E\,A = 300 - 189.44 = 110.56 \text{ ft. Ans.}$$

63. Show portion of hill, containing two depressions or ravines, approximately parallel, starting from nothing a little below the top and reaching a considerable depth before debouching upon the plain below. A swelling ridge to occupy space between the ravine's hachures.

Fig. 1. Page 52.

64. Show a fresh water pond with in- and out-going stream, marshy shore and small wood island.

Fig. 2.

65. Show a farmhouse, stable, outhouse, orchard, cultivated land, stone fences, wooded land, brook and pond, road bushes and uncultivated land.

Fig. 3.

66. Show a hill, 100 ft. high, represented by hachures showing differences of elevation of 10 ft.

Fig. 4.

67. Show same hill as in Q. 66 by contours.

Fig. 5.

68. Show a reservoir and dam, with wide stream above and below.

Fig. 6.

69. Show an abrupt rocky shore with sand beach.

Fig. 7.

70. Show a dwelling house with walks, drives, shade trees, garden, kitchen garden and orchard.

Fig. 8.

STRUCTURAL STEEL DRAFTSMAN.

71. Define (*a*) moment of inertia, (*b*) radius of gyration, (*c*) section modulus, (*d*) neutral axis.

(*a*) The moment of inertia of an area or section about any axis in the same plane is the sum of the products obtained by multiplying each infinitesimal portion of the area by the square of its distance from the axis.

(*b*) The radius of gyration about any axis is the square root of the quotient obtained by dividing the moment of inertia about that axis by the area of the section.

(*c*) The section modulus is the quotient obtained by dividing the moment of inertia of the section about the neutral axis by the distance from that axis to the extreme fiber.

FIG. 1.

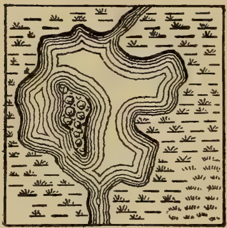


FIG. 2.

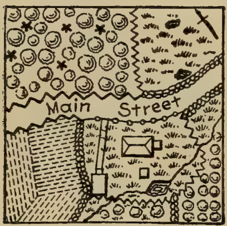


FIG. 3.

FIG.

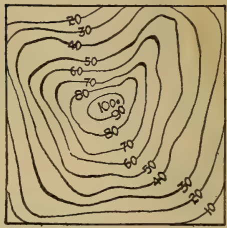


FIG. 5.

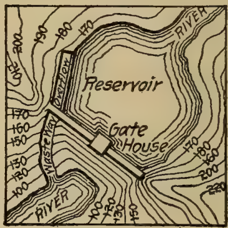


FIG. 6.

FIG. 7.

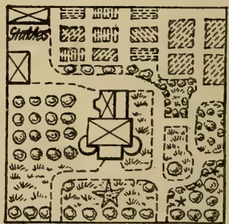


FIG. 8.

(*d*) The neutral axis is the line passing through points at which there is no internal tension or compression.

72. What unit stresses would you assume as safe in the use of medium steel (*a*) for a city bridge under heavy traffic; (*b*) for a bridge for ordinary highway traffic; (*c*) for a roof truss?

	Member.	(*a*) lbs. per □″	(*b*) lbs. per □″	(*c*) lbs. per □″
Tension.				N.
	Floor beam hangers, etc.	6 000	8 000	
	Long. Lat. and sway bracing, wind.	18 000	18 000	
	" " " " " , live load	12 000	18 000	
	Rolled beams, used as fl. b'ms, etc.	10 000	13 000	
	Bottom flanges of riveted girders..	10 000	13 000	
	Tension members of trusses, dead load	20 000	25 000	16 000
	Tension members of trusses, live load	10 000	12 500	16 000
Compression.	Chord segments, live load	$p = 10\,000 - 45\frac{l}{r}$	$p = 12\,000 - 55\frac{l}{r}$	
	" " dead "	$p = 20\,000 - 90\frac{l}{r}$	$p = 24\,000 - 110\frac{l}{r}$	
	Posts of through bridges, live	$p = 8\,500 - 45\frac{l}{r}$	$p = 10\,000 - 45\frac{l}{s}$	
	" " " " dead	$v = 17\,000 - 90\frac{l}{r}$	$p = 20\,000 - 90\frac{l}{r}$	
	Posts of deck bridges and trestles, live	$p = 9\,000 - 40\frac{l}{r}$	$p = 11\,000 - 40\frac{l}{r}$	$17\,000 - 57\frac{l}{r}$
	Post of deck bridges and trestles, dead	$p = 18\,000 - 80\frac{l}{r}$	$p = 22\,000 - 80\frac{l}{r}$	
	Shear on shop rivets	9 000 lbs. □″	10 000	10 000
	Bearing on " "	15 000	18 000	20 000

The above values are fairly representative.

73. State the various loads employed to get the stresses in (*a*) fixed highway bridges; (*b*) fixed railway bridges.

(*a*) 1. Dead weight of the bridge, including trusses, floor system and bracing, roadway, sidewalk, etc.

2. Live load of 100 lb. per sq. ft. on the bridge (excluding space occupied by tracks).

3. Moving live load, representing heaviest street cars that may pass over the bridge.

4. A uniform wind load considered acting horizontally.

5. A moving wind load acting horizontally.

(*b*) 1. Dead and wind loads same as in highway bridges.

2. A system of concentrated loads on the tracks, representing the wheel loads of the heaviest engines that may pass over the bridge.

74. State what loads are used per square foot for office, school floors, floors of warehouses for heavy goods, for public assembly rooms, etc.

Office, 150 lb. per sq. ft., first floor; 75 lb. per sq. ft., upper floors.
School, 75 lb. per sq. ft.
Warehouses, 150 lb. per sq. ft., heavy storage.
Warehouses, 120 lb. per sq. ft., light storage.
Assembly, 90 lb. per sq. ft.
Factory, 150 lb. per sq. ft.
Hotels, tenements, etc., 60 lb. per sq. ft.

75. Explain Gordon's formula and give the three applications of its use.

The usual form of Gordon's formula for long columns is

$$P = \frac{f\,S}{1 + a\,\frac{l^2}{r^2}},$$

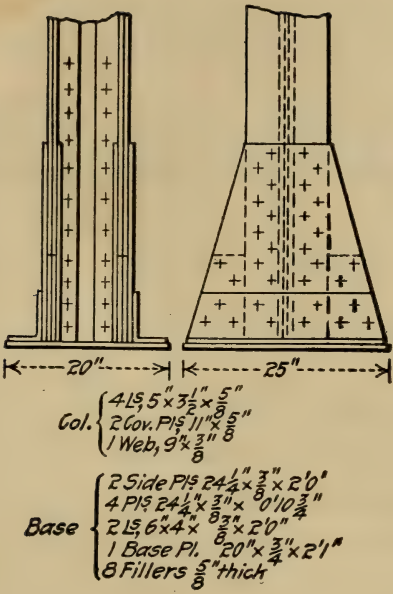
in which

P = ultimate strength of column, in pounds.
f = ultimate compressive strength, in pounds per square inch.
S = cross-sectional area of column, in square inches.
l = length of column, in inches.
r = least radius of gyration of column, in inches.
a = constant, determined by experiment; being smallest for "fixed" end columns, greatest for "pin" end columns, and intermediate for "pin and square" end columns.

The three different cases arising in the application of Gordon's formula are:

1. "Fixed" end columns.
2. "Pin" end columns.
3. "Pin and square" end columns.

76. Make sketch for a steel built-up column footing to transmit to masonry foundation a load of 200 tons.



Assume 15 000 lb. per sq. in. bearing on rivets.

7 500 " " " " shear on rivets.

800 " " " " bearing on granite.

$$\frac{400\ 000}{8\ 00} = 500 \text{ sq. in., base plate.}$$

Use plate, 20 × 25 in., giving 500 sq. in.

Use $\frac{7}{8}$-in. rivets; double shear per rivet = 9 020 lb.; bearing on two $\frac{3}{8}$-in. side plates = 9 850 lb.

$$\frac{400\ 000}{9\ 020} = 44 \text{ rivets needed to connect side plate to column proper.}$$

The arrangement of side plates, as shown, distributes load over the whole base plate.

The side plates give an aggregate bearing area of about 34 sq. in. on the base plate.

$$\frac{400\ 000}{34} = 11\ 750 \text{ lb. per sq. in., which is well within safe limits.}$$

These calculations are on the assumption that the side plates distribute the whole column load to the base plate. In practice, the column is faced before the base plate is connected up, thus making the column proper bear on the base plate also; but if we consider the whole load to be taken directly to the base plate by the column, we get too great an intensity of pressure on the foundation directly

under the column. It is therefore on the side of safety to consider the load distributed upon the foundation by the side plates only.

77. Design a stone footing of courses 2 ft. thick for a load from a column of 250 tons, for ground which will take 4 tons per sq. ft. safely.

Area required for bottom course $= \frac{250}{4} = 62.5$ sq. ft.

Let bottom course be 8 ft. by 8 ft., giving 64 sq. ft. of area.

Assuming that specifications allow 800 lb. per sq. ft. bearing on granite cap-stone, then

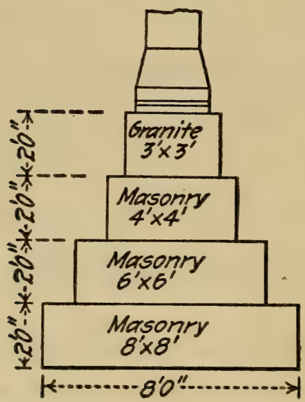
Area of base plate of column $= \frac{250 \times 2\,000}{800} = 625$ sq. in.

$\sqrt{625} = 25$ in., making base plate 25 by 25 in.

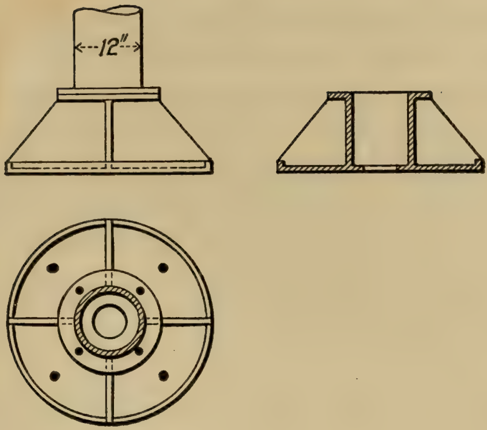
Assume safe bearing of granite cap on masonry at 400 lb. per sq. in., then bearing area of granite cap $= \frac{250 \times 2\,000}{400} = 1\,250$ sq. in.

$\sqrt{1\,250} = 35 +$ inches; use cap 36 by 36 in.

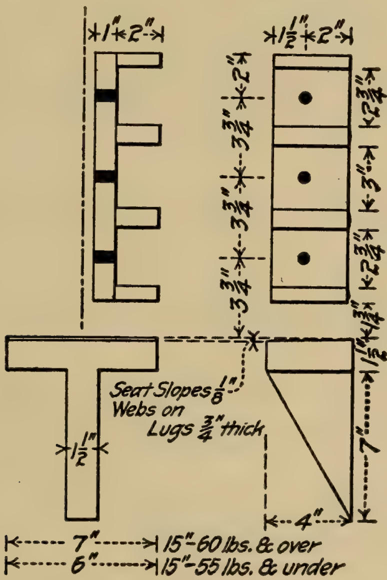
The sketch, which gives sufficient room for base plate, shows complete design.



78. Show by sketches a cast-iron column base for a 12-in. round column.



79. Show by sketches the usual connection of a cast-iron column for a 15-in. I-beam.



80. What points must be considered in designing columns?

1. Loads should be applied to columns centrally wherever possible, eccentric loading being avoided.

2. The ratio of unsupported length to least radius of gyration $\left(\frac{l}{r}\right)$ must not exceed 120 in building work. and 100 in bridge work for steel columns. When cast-iron columns are used in buildings $\left(\frac{l}{r}\right)$ must not exceed 70.

3. Bearing plates must be used between cast-iron columns placed upon one another, least thickness of metal allowed being $\frac{3}{4}$ in.

4. When shapes are used they must be so arranged as to facilitate the work of riveting them together.

5. The base and top of any column must be made truly perpendicular to the length by facing, if necessary.

81. (*a*) What is the least proportion of depth a plate girder should have to the span? (*b*) In general how should stiffeners be spaced?

(*a*) In railroad bridges the depth of a plate girder should not be less than $\frac{1}{10}$ to $\frac{1}{12}$ of the span; in highway bridges the depth may be as small as $\frac{1}{20}$ of the span.

(*b*) Stiffeners must be placed over bearing points and at points of concentrated loadings. In general they are placed at intervals not exceeding the depth of the girder, or a maximum of 5 ft. (in railroad bridges), wherever the shearing strain per square inch exceeds the following: Allowed shearing strain $= 10\,000 - 75\ H$, where $H =$ ratio of depth of web to its thickness.

82. (*a*) How is the strength of a rivet computed; (*b*) also about what constants would you adopt for steel rivets in such a computation?

(*a*) The strength of a rivet is computed for shear and bearing. Bending in rivets is usually ignored. The shearing strength (single shear) of a rivet is equal to the area of its cross-section multiplied by the allowable shear per square inch. For double shear the strength of the rivet is twice this amount; for quadruple, four times.

The bearing strength of a rivet is calculated as follows:

Let $d =$ diameter of rivet, in inches.
$t =$ thickness of plate upon which rivet bears (in inches).
$b =$ bearing allowed per square inch.
$B =$ bearing strength of rivet.

Then $B = b\ d\ t.$

(*b*) The New York City Building Code allows 10 000 lb. per sq. in. shear and 20 000 lb. per sq. in. bearing for shop rivets. Lower values than these are allowed for highway and railroad bridges. The American Bridge Company increases the live-load stresses in structures by 25% and then allows 11 000 lb. per sq. in. shear and

22 000 lb. per sq. in. bearing. For field rivets these values are usually decreased 20 per cent.

83. Would you adopt the same constants for field rivets as for shop driven, and what reasons can you give for your decision?

No. Smaller constants should be allowed for field-driven rivets, because it is easier to make well-driven rivets in the shop than in the field, and the chances of discovering badly-driven rivets in the field are not so good as in the shop.

NOTE.—For hand-driven field rivets most authorities allow 20% less in the constants than for shop. Cooper allows only $66\frac{2}{3}$% of the constants for field-driven rivets. When field rivets are machine driven, about 10% is the usual reduction in constants.

84. Is there any rule, and if so what, (*a*) for the minimum and maximum distances between rivets in riveted floor beams or columns; (*b*) for the minimum distance from the rivet hole to the edge of any piece?

(*a*) The pitch of rivets, in the direction of the strain, must not exceed 6 in., nor 16 times the thickness of the thinnest outside plate connected, and not more than 30 times that thickness at right angles to the strain. The minimum pitch of rivets is three times the diameter of the rivet.

At the end of compression members pitch must not exceed four diameters of rivet for a length equal to twice the width of the member.

(*b*) The distance from the edge of any piece to the center of a rivet hole must not be less than $1\frac{1}{2}$ times the diameter of the rivet, nor exceed 8 times the thickness of the plate.

85. (*a*) Give the rules for rivet spacing.

(*b*) What are the general notes on shop drawings in regard to rivet holes?

(*a*) 1. The pitch shall not be less than three diameters of the rivet.

2. The pitch shall not be greater than 6 in. nor than 16 times the thinnest outside plate.

3. The pitch at the end of compression members shall not exceed 4 diameters of the rivet for a length equal to twice the width of the member.

4. The distance between the edge of any piece and the center of the rivet hole must not be less than $1\frac{1}{4}$ in., preferably $1\frac{1}{2}$ diameters of rivet, except for bars less than $2\frac{1}{2}$ in. wide.

5. The unsupported width (distance between rivets) of plates subject to compression shall not exceed 30 times their thickness, ex-

cept cover plates of top chords, which shall preferably be limited to 40 times their thickness.

(*b*) The general notes on shop drawings are as follows: All rivets, $\frac{7}{8}$ in. diameter unless noted; open holes, $\frac{15}{16}$ in. diameter unless noted.

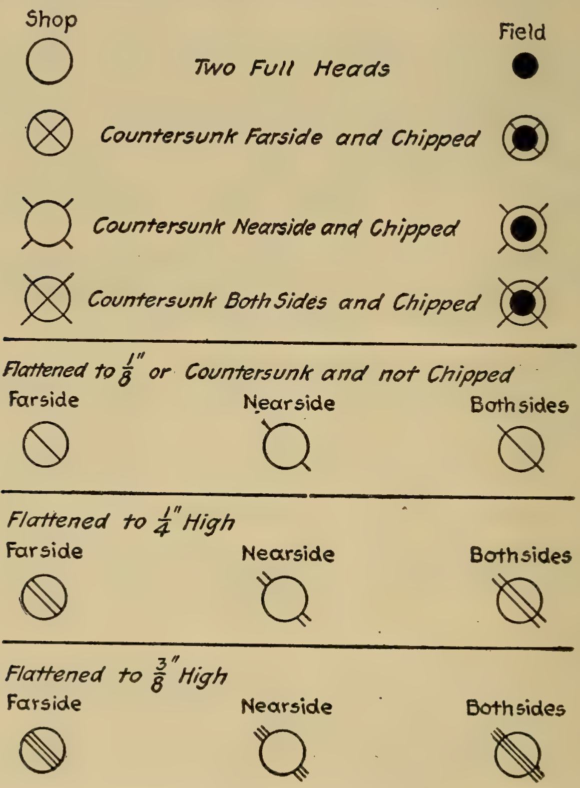
86. What should be the actual size of punched rivet holes for $\frac{7}{8}$-in. rivets? (*b*) What size is assumed in calculating net sections?

(*a*) $\frac{15}{16}$ in. diameter.
(*b*) 1 in. diameter.

87. How close can $\frac{3}{4}$-in. rivets be driven (*a*) to each other, (*b*) to the edge of the piece?

(*a*) $3 \times \frac{3}{4}$ in. $= 2\frac{1}{4}$ in.
(*b*) $1\frac{1}{2} \times \frac{3}{4} = 1\frac{1}{8}$ in. (usually $1\frac{1}{4}$ in.).

88. Show the conventional signs for rivets and field holes.

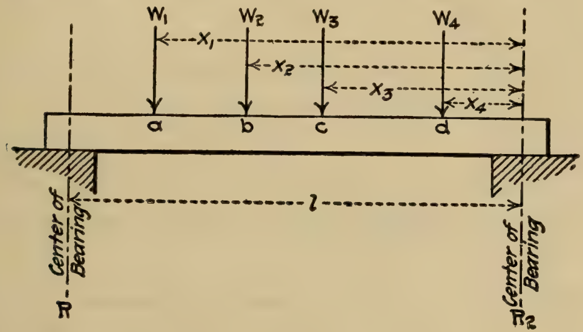


89. How is the strength of a rod having a screw thread on it calculated, and in what case can the full strength of the rod be considered available?

In calculating the strength, the effective cross-section is taken through the root of the threads. There must always be such a number of threads in the nut that the liability of the threads to shear off is less than that of the failure of the body of the rod.

The full strength of the rod is available when the ends are upset so that the section through the roots is equal to or greater than the section of the body of the rod.

90. Suppose a beam supported at its extremities to carry three or more loads; describe the operation of finding (*a*) the shear at any point; (*b*) the maximum moment.



Let l = span in feet.

W_1, W_2, etc., = concentrations at a, b, c and d, expressed in pounds.

x_1, x_2, x_3, x_4 = feet from R_2.

Then $R_1 = \frac{1}{l}(W_1 x_1 + W_2 x_2 + W_3 x_3 + W_4 x_4)$.

(*a*) And shear at $a = R_1$.

" " $b = R_1 - W_1$.

" " $c = R_1 - (W_1 + W_2)$.

" " $d = R_1 - (W_1 + W_2 + W_3)$.

or " " $d = R_2$.

That is, the shear at any point is equal to the algebraic sum of all the forces to either side of that point (calling upward forces plus and downward minus).

(*b*) Moment at $a = R_1 (l - x_1)$,

" " $b = R_1 (l - x_2) - W_1 (x_1 - x_2)$,

" " $c = R_1 (l - x_3) - W_1 (x_1 - x_3) - W_2 (x_2 - x_3)$,

" " $d = R_2 \times x_4$.

That is, the moment at any section is equal to the algebraic sum of the moments of all the forces on either side about that section.

The largest of these is the maximum moment.

NOTE.—The shears and moments due to weight of beam itself have been neglected, but in a heavy girder they are added to those found above.

91. Explain how an I-beam is designed for uniform load. Explanation of handbook table will receive proper consideration.

Let l = length of span.
w = uniform load per foot of beam, including its own weight.
k = allowable fiber stress, about 12 000 lb. per sq. in. for bridge work; 16 000 lb. per sq. in. for building work.
s = section modulus of beam or girder, as given in handbook.

Then $M = \frac{w\,l^2}{8}$ = external bending moment.
$= k\,s$, the resisting moment of beam.

In the table of "Properties of I-beams," look up that value of s which, multiplied by k, will most nearly equal the value of M found above. The product, $k\,s$, must not be less than M. The beam whose section modulus answers the above requirements should be selected.

92. What are the maximum moment and reactions of a girder 20 ft. long with a concentrated load in center of 15 000 lb. and a uniform load of 2 000 lb. per lin. ft. of girder?

$$\text{Moment for uniform load} = \frac{2\,000\,(20)^2}{8} = 100\,000 \text{ ft.-lbs.}$$

$$\text{" \quad " concentrated load} = \frac{15\,000 \times 20}{4} = \underline{75\,000} \text{ ft.-lbs.}$$

$$\text{Maximum moment at center} = 175\,000 \text{ " \ "}$$

$$\text{Reaction due to uniform load} = \frac{2\,000 \times 20}{2} = 20\,000 \text{ lbs.}$$

$$\text{" \quad " to concentrated load} = \frac{15\,000}{2} = \underline{7\,500} \text{ "}$$

$$\text{Maximum reaction} = 27\,500 \text{ "}$$

93. What is the required net section of lower chord in above girder if the effective depth is 2 ft. and the allowable tension is 12 000 lb. per sq. in.?

$$\text{Required net section} = \frac{175\,000}{2 \times 12\,000} = 7.29 \text{ sq. in.}$$

94. State how you would compute the necessary number, spacing, and dimensions of stiffeners at the end of a plate girder.

The gross cross-sectional area of the end stiffeners must be sufficient to take the reaction, allowing such an intensity per square inch as the specifications permit. A suitable number of stiffeners must be used to give this gross area. In case of a heavy girder resting on a bearing plate or casting, the stiffeners must be spaced so as to distribute the load as uniformly as possible on the plate or casting; they must be of such dimensions as to make a neat and workmanlike finish.

In general, stiffeners are spaced at intervals not exceeding the depth of the girder, with a maximum of 5 ft. wherever the shear per square exceeds that allowed by the specifications.

95. In a plate girder made up of a web, cover plates and angles, state how you would determine the economical lengths of the plates where several thicknesses are used in each flange?

For a girder with uniform load,

Let A = total cross-sectional area of flange at center, including plates and angles (square inches).

a = cross-sectional area of outside plate in sq. in.

a' = area of next plate.

a'' = area of third plate; etc.

L = length of outside plate in ft.

L' = " of next " " "

L'' = " of third " " " etc.

l = dist. c. to c. of bearings, in ft.

Then $L = l\sqrt{\frac{a}{A}} + 1$ ft.

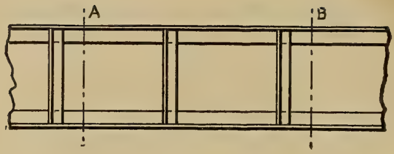
$$L' = l\sqrt{\frac{a + a'}{A}} + 1 \text{ ft.}$$

$$L'' = l\sqrt{\frac{a + a' + a''}{A}} + 2 \text{ ft. (for inmost plate).}$$

For girders with concentrated loading, the graphical method of getting the lengths of cover plates is the best.

NOTE.—The graphical method is well explained in Kidder's "Architect's Handbook."

96. State how you would compute the number of rivets required in any given length of the flanges of a plate girder.



Let F_1 = flange stress at A.

F_2 = " " " B.

b = smallest bearing value of 1 rivet.

s = " shearing " " 1 "

n = number of rivets required in each flange between A and B.

Then

$$n = \frac{F_1 - F_2}{b}.$$

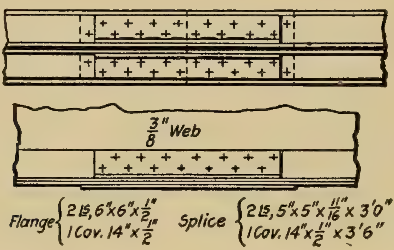
If s is smaller than b we have

$$n = \frac{F_1 - F_2}{s}.$$

To get the flange stress at any point, divide the B. M. at that point by the effective depth of the girder.

97. Design a splice for a tension flange of a plate girder composed of two 6 by 6 by $\frac{1}{2}$-in. angles and one 14 by $\frac{1}{2}$-in. cover.

The best method of splicing the flange of a plate girder is to splice the cover plate at a different point than the angles, and in splicing the angles the single lengths of angle on one side of the web are made to break joints with the lengths on the other side. This method insures the greatest amount of continuous material at any splicing point. In some cases it may be necessary or expedient to splice both the angles and the cover plate at the same point. Assume that the whole flange is spliced at the same point.



Flange $\begin{cases} 2 \text{ L's } 6'' \times 6'' \times \frac{1}{2}'' \\ 1 \text{ Cov. } 14'' \times \frac{1}{2}'' \end{cases}$ Splice $\begin{cases} 2 \text{ L's } 5'' \times 5'' \times \frac{11}{16} \times 3'\ 0'' \\ 1 \text{ Cov. } 14'' \times \frac{1}{2}'' \times 3'\ 6'' \end{cases}$

Allow 16 000 lbs. per sq. in. tension in flange.
20 000 lbs. " " " bearing on rivets.
10 000 lbs. " " " shear on rivets.

Then bearing of $\frac{7}{8}''$ shop rivet on $\frac{1}{2}''$ pl. = 8 750 lbs.
" " $\frac{7}{8}''$ " " " $\frac{3}{8}''$ " = 6 570 "
single shear " $\frac{7}{8}''$ " " = 6 010 "

To splice the 14" × $\frac{1}{2}''$ cov. pl. use a 14" × $\frac{1}{2}''$ pl. giving the same capacity.

2 — 6" × 6" × $\frac{1}{2}''$ L's = 11.50 sq. in. gross.
4 × $\frac{1}{2}''$ × 1" = 2.00 " " taken out for 2 rivets in each angle.
2 — 6" × 6" × $\frac{1}{2}''$ L's = 9.5 " " net.

2 — 5" × 5" × $\frac{11}{16}''$ L's = 12.84 " " gross.
4 × $\frac{11}{16}''$ × 1" 2.75 " " taken out for 2 rivets in each angle.
2 — 5" × 5" × $\frac{11}{16}''$ L's = 10.09 " " net.

As 2 — 5" × 5" × $\frac{5}{8}''$ angles give only 9.22 sq. in. net, use 2 — 5" × 5" × $\frac{11}{16}''$ angles to splice the 2 — 6" × 6" × $\frac{1}{2}''$ flange angles.

Net area of cover plate or of splice plate is 12" × $\frac{1}{2}''$ = 6 sq. in.

6 × 16 000 = 96 000 lbs. capacity of splice.

$\frac{96\ 000}{6\ 010}$ = 16 rivets needed in cover splice.

(The drawing shows 16 rivets.)

Net area of 2 — 6" × 6" × $\frac{1}{2}''$ L's is 9.5 sq. in. 9.5 × 16 000 = 152 000 lbs. capacity of the angles.

The rivets in the angle splices are in double shear in the vertical legs, and in single shear in the horizontal legs. These values are each less than the corresponding bearing values.

14 rivets @ 6 010 lbs. = 84 140 lbs.
7 rivets @ 12 020 lbs. = 84 140 "

Total capacity of rivets in single splices = 168 280 "

As the rivets in the angle splice have to carry only 152 000 lbs., the above arrangement is on the side of safety. A smaller number of rivets would not give as convenient an arrangement of rivet holes, and would give practically no saving in material of splice.

98. What advantage has an 18-in. I of 55 lb. per ft. over a 15-in. I of equal weight? If 15-in. I will carry the load, what is the advantage in its use?

An 18-in. I, 55 lb., has a greater section modulus than a 15-in. I of 55 lb.; it can therefore stand a greater bending moment; that

is to say, for a given span it can carry a heavier load or for a given load it can span a greater distance.

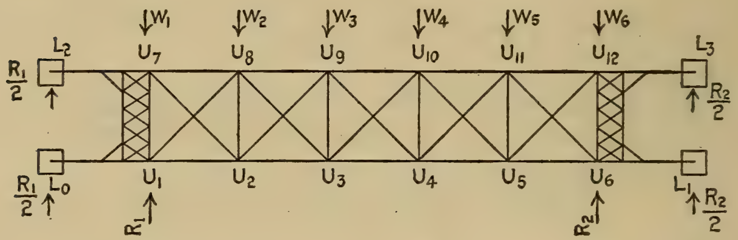
The advantage of using a 15-in. I is that it will make a shallower floor and will therefore give a greater vertical clearance.

99. What is the least bearing a beam should have on masonry?

Every wooden beam, except header and tail-beams, must rest at one end 4 in. in the wall or upon a girder.

Steel beams must have enough bearing on the masonry so as not to exceed the safe bearing pressure.

100. In a through truss how are the stresses in the diagonals between the upper chords transmitted to the masonry at the ends?



The above is a plan of the upper lateral and the portal bracing. The upper lateral system is calculated as a truss with panel loadings equal to the wind pressure per panel, the ends of the truss being at U_1 and U_6.

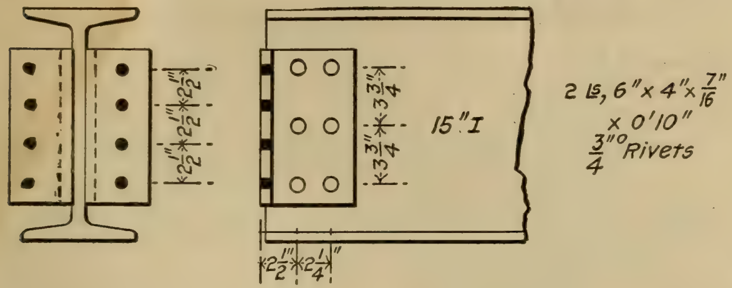
Let R_1 and R_2 be the reactions of this truss. These reactions are carried down to the masonry by means of the portal bracing, causing bending in the end posts; $\frac{1}{2}$ R_1 is considered acting at L_0 and L_2, and $\frac{1}{2}$ R_2 at L_1 and L_3. Anchor bolts at the points L_0, L_2, L_1 and L_3 take the shears due to these reactions and transmit them to the masonry.

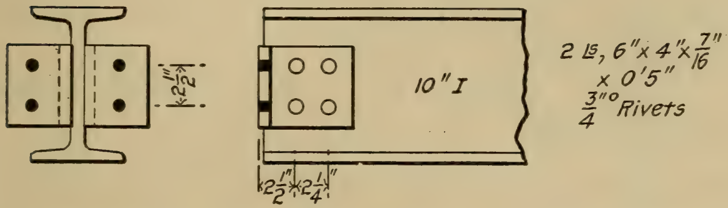
101. (*a*) What are the largest sections of I-beams, channel and angle, rolled? (*b*) What the lightest weight of 20-in. and 18-in. beams?

(*a*) 24-in. I, 100 lb. per lin. ft.
15-in. I, 55 lb. per lin. ft.
8 by 8-in. by 1⅛ in. angle, 56.9 lb. per lin ft.

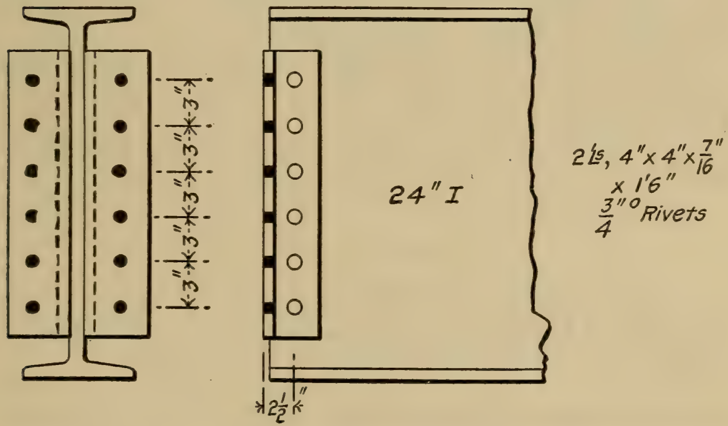
(*b*) 20-in. I, 65 lb. per lin. ft.
18-in. I, 55 lb. per lin. ft.

102. Show by sketches the standard connection angle of a 15-in. and a 10-in. I-beam.





103. Sketch standard angle connections for 24-, 15- and 8-in. I's'.



For 15 and 8-in. I's see Question No. 102; the standard connections for 8-in. I and 10-in. I are the same.

104. In designing a roof truss, what are the loads to be considered and how are these determined?

I.—Dead load.
- (*a*) Weight of truss, purlins and bracing.
- (*b*) Weight of roof covering.
- (*c*) Weight of loading attached to roof, if any.

II.—Live load.
- (*a*) Snow load.
- (*b*) Wind load.
- (*c*) Weight of crowd of people, if roof is flat and is to be used as a roof garden or for similar purposes.

In I *a, b* and c are found by calculating the actual weights of materials used, the weight of truss and purlins being obtained from a similar existing roof, if possible; or tentative values are used, the roof designed and its weight then calculated, this procedure being employed several times if necessary until the weight of roof as designed agrees fairly well with the assumed weight.

In II the snow load is determined by the climatic conditions in the locality where the roof is to be used. In the vicinity of New York City about 12 to 15 lb. per sq. ft. is a fair value.

The wind load is taken out of empirical tables on the force of winds calculated for the locality. It is considered acting normal to the roof and on one-half the roof at a time. (For a horizontal wind pressure of 40 lb. per sq. ft., the highest usually employed in this country, the normal pressure on a roof sloping 5° is about 5 lb. and increases for different slopes becoming 40 lb. for a roof sloping 60°. These values are obtained from Unwin's formula.)

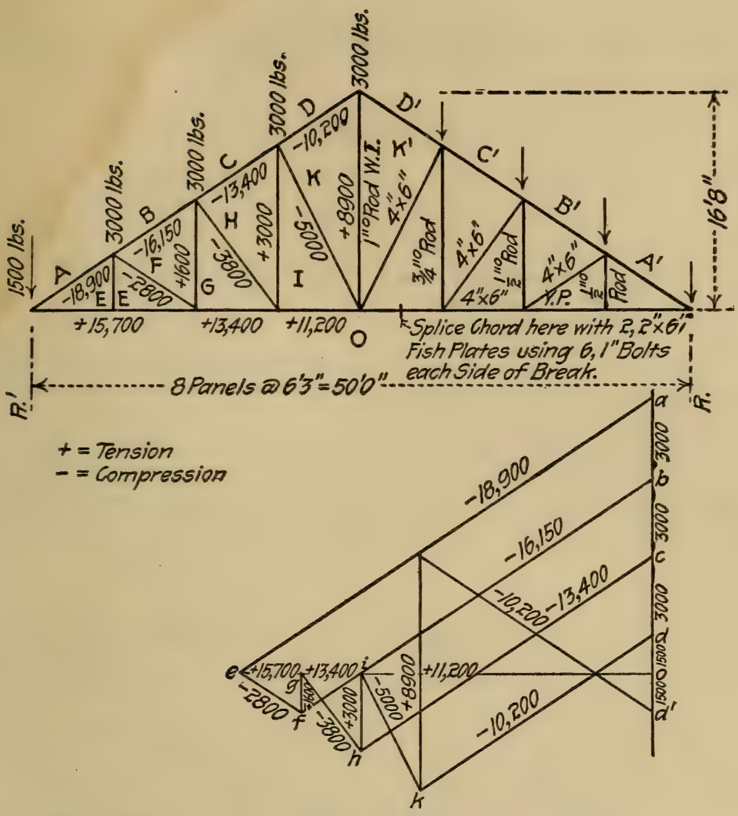
For wooden trusses the snow and wind loads are usually combined and considered as a vertical load of about 20 lb. per sq. ft. in the northern part of the United States.

The weight of a crowd of persons varies from about 80 to 100 lb. per sq. ft.

105. Given a roof truss with rise equal to one-third of span, span equal to 50 ft., trusses 16 ft. apart, total load over the whole surface 30 lb. per sq. ft. of horizontal projection. Design truss.

Assume outline of truss as shown. $16 \times 50 \times 30 = 24\,000$ lb., total load on truss. $\dfrac{24\,000}{8} = 3\,000$ lb. panel load.

Draw stress diagram as shown; it is not necessary to complete the whole diagram for symmetrical trusses with uniform vertical loading. The hanger *E E* is not a member of the truss and therefore does not appear in the stress diagram.



Allow 800 lbs. per sq. in. compression on Y. P. timber.

Allow 1 200 lbs. per sq. in. tension on Y. P. timber.

Allow 12 000 lbs. per sq. in. tension on wrought iron.

$A\ E,\ \dfrac{18\ 900}{800} = 23.6$ sq. in. required. Use 1 — 6″ × 6″ Y. P. timber for whole length of rafter. This allows for cutting.

$E\ O,\ \dfrac{15\ 700}{1\ 200} = 13.1$ sq. in. required. Use 4″ × 6″ Y. P. for the whole bottom chord in two lengths spliced near centre.

$K\ I,\ \dfrac{5\ 000}{800} = 6.3$ sq. in. required. 2″ × 3″ would do; 4″ × 6″ is better, making $\dfrac{l}{d} = 42$.

$K\ K',\ \dfrac{8\ 900}{12\ 000} = 0.74$ sq. in. required. Use 1″ round rod with ends upset.

HI, $\frac{3\,000}{12\,000} = 0.25$ sq. in. required. Use $\frac{3}{4}$-in. round rod, ends upset.

FG, $\frac{1\,600}{12\,000} = 0.13$ sq. in. required. Use $\frac{1}{2}$-in. round rod, ends upset.

106. What is "shear" in a truss with horizontal chords, and how is it determined at any point?

The shear at any point in a truss with horizontal chords is the algebraic sum of all the external vertical forces acting on the truss to either side of the point.

To determine the shear, take the algebraic sum of all the vertical loads to either side of the point, calling the reaction plus and the panel loads minus. The shears calculated for either side will be numerically equal, but of opposite sign.

107. (*a*) What is the object of camber in a bridge truss? (*b*) State how you would provide the proper amount in any given case.

(*a*) Camber is given to a bridge truss so that the lower chord will not deflect below a horizontal line when the maximum load comes upon the bridge. The object is largely a matter of appearance.

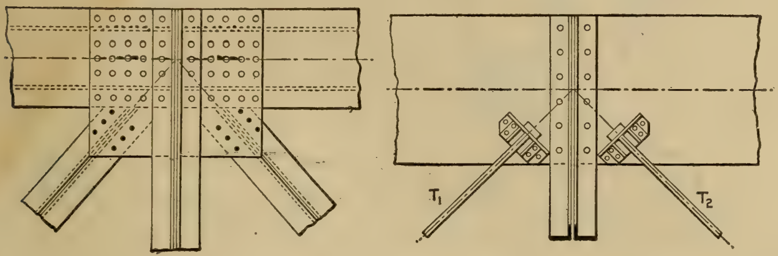
(*b*) The usual rule for highway and railroad bridges is to give the panels of the top chord an excess of length in the proportion of $\frac{1}{8}$ in. to every 10 ft. The theoretical length of the diagonals must then be recalculated for the new dimensions given to the top chord.

In some cases a deflection diagram is worked out after the bridge has been tentatively designed, and then suitable changes are made in the lengths of the members to bring the lower chord horizontal under full live load.

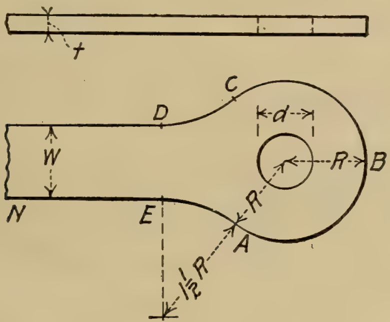
108. What is the best way for attaching horizontal diagonals to the upper chords of a truss? Give sketch.

If the diagonals consist of angles they should be riveted either directly to the top chord or to a gusset plate attached to the chord. If they consist of rods, the rods may be attached to an angle iron

riveted to the top chord and stiffened by other iron angles, or the rod may be held in place by a pin passing through a gusset plate attached to the chord.



109. Give sketch of a well-proportioned eye-bar head and pin with relative dimensions.



Let w = width of bar in inches.

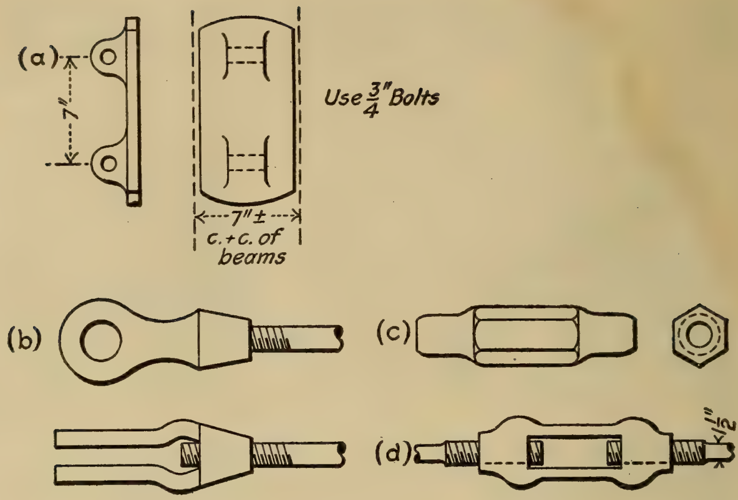
Then $t = \frac{1}{4} w$ to $\frac{1}{6} w$ (thickness of bar).

$d = 0.75\ w$ to w = diameter of pin.

$R = \frac{d}{2} + (0.75\ w \text{ to } 0.9\ w)$ = radius of portion $A\ B\ C$.

circular arc $E\ A$ is tangent to $C\ B\ A$ and to $N\ E$.

110. Make a neat sketch for (*a*) cast-iron separator for 15-in. beams; (*b*) clevis; (*c*) sleeve-nut; (*d*) turn-buckle for $1\frac{1}{2}$-in. rod.



111. How would you secure transverse or wind bracing in a building where cast-iron columns are used?

Fasten the bracing to lugs cast on the columns.

112. What is the object of tie rods? Describe or show by sketch how they should be arranged for several beams of 20 ft. span.

The object is to take the thrust of the arch flooring, built between two adjacent beams.

Holes for tie rods should be placed as near the thrust of the arch as possible. The distance between tie rods in floors should not exceed 8 ft. nor 8 times the depth of beams 12 in. and under.

The distance between holes for rods on opposite sides of beams is about 3 in. horizontally.

113. What points must be considered in designing floor construction and connections?

1. The beams must be spaced so as to fit standard fire-proof construction.

2. The beams should be as shallow as possible so as not to give too deep a floor.

3. Deflection of beams under load must not exceed $\frac{1}{30}$ in. per ft. of span if plastered ceiling is fastened to them.

4. The beams must be able to carry the heaviest loads that may come upon them.

5. Standard connections should be used wherever possible, and in any case the connection must be strong enough to take the end shear on the beam.

114. Is it sufficient in designing a floor to consider only the supporting power of the beams, or is there a limit to the loading for some other cause, and if so, what?

No. The load on beams is also limited by the danger of the ceiling cracking. In plastered ceilings this has been found to occur when the deflection exceeds $\frac{1}{360}$ of the distance between supports, or $\frac{1}{30}$ in. per ft. of span.

115. In making a working drawing for a casting, such as a bed plate or other design of somewhat complicated form, what must be done to insure sound castings, in so far as the draftsman can aid in so doing?

All parts of the casting should be made of nearly the same thickness so that the casting can cool off uniformly.

The casting should be designed so that cores can be easily removed.

Allow "draft" of about $\frac{1}{8}$ in. per ft. for shrinkage.

All corners should be filleted.

116. In a casting, what is draft? How much is it proper to allow? What other points are to be observed in designing castings?

"Draft" is a taper allowed in castings so as to facilitate removal from the moulds. This allowance is for shrinkage in the material as it cools, and is equal to about $\frac{1}{8}$ in. per ft. for cast iron.

See also Question 115.

117. What are the least proper clearances to allow between (*a*) 8-in. pin and pin-hole; (*b*) 2-in. pin and pin-hole?

(*a*) $\frac{1}{32}$-in.
(*b*) $\frac{1}{50}$-in.

118. What is the (*a*) "elastic limit"; (*b*) the "ultimate resistance"; (*c*) the coefficient of elasticity?

(*a*) The elastic limit is the highest intensity to which any material can be strained in tension without giving it a permanent stretch.

(*b*) The ultimate resistance is the highest intensity to which any material is strained, just before failure.

(c) Let p = intensity of tension, to which any material is subjected (up to the elastic limit).
l = elongation per unit of length, for above tension.
E = coefficient of elasticity.

Then $E = \frac{p}{l}$.

119. Discuss the value of wrought-steel and cast-iron columns.

Cast-iron columns are easily manufactured in almost any shape, cheap, and well adapted for architectural effects.

However, they are unreliable as to uniform section and strength, may have internal strains and blowholes, and it is difficult to attach good wind bracing to them.

Wrought-steel columns are very reliable as to strength and are lighter than cast-iron columns of same capacity, well adapted for all kinds of connections and stronger for eccentric loading than cast-iron columns.

They are more expensive than cast-iron columns, and entail more work in manufacture.

120. (a) What assumptions are made in the "common theory" of flexure? (b) What is the formula for bending as given by this theory?

(a) Two assumptions are made: First, that all plane sections normal to the neutral axis remain plane after flexure. Second, that the intensity of either the tensile or compressive stress in any section normal to the neutral axis of the beam varies directly as the distance from the axis.

(b) $M = \frac{KI}{d}$, where,

M = bending moment at any section of a beam, girder or column subjected to transverse loading.
I = Moment of inertia at that section.
d = distance from neutral axis to extreme fiber at the section.
K = intensity of stress at the extreme fiber.

MANUAL OF EXAMINATIONS

FOR

ENGINEERING POSITIONS

IN THE

SERVICE OF THE CITY OF NEW YORK

QUESTIONS AND ANSWERS

IN 3 VOLUMES

VOL. I. AXEMAN, CHAINMAN AND RODMAN, LEVELER, TRANSITMAN AND COMPUTER
VOL. II. ASSISTANT ENGINEER
VOL. III. DRAFTSMAN, AND INSPECTOR

VOL. III. PART II

INSPECTOR

MASONRY, BUILDING, STEEL, REGULATING, GRADING AND PAVING, SEWERS

INDEX

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PREFACE.

In the "Previous Examination Papers" which have been included in this book, the questions may not, in all cases, be identical in wording with those actually given at the examinations, as copies of the original papers are not readily procurable, but they embody the substance of the questions asked.

In the section devoted to "Typical Questions and Answers," the answers indicate in a general way only what is required of the candidate, and are not intended to be perfect, as reasonable variance of opinion may exist as to what is the best answer in many cases, owing to differences in interpretation of the questions and in education and experience of the candidate. Answers to many questions given at other examinations bearing upon the work of inspectors have been included in this part for the benefit of the candidate. A number of these are taken from Vol. II of the Manual of Examinations.

In order to perpetuate the value of the book blank leaves have been inserted after the "Previous Examination Papers," allowing for the convenient addition of new sets, and the "Typical Questions and Answers" have been interleaved to provide space for notes, sketches and additions.

PREVIOUS EXAMINATION PAPERS.

BUILDING INSPECTOR—MASONRY AND CARPENTRY.

TECHNICAL.

1. Describe the characteristics of good concrete for foundation, including method of selecting the materials, mixing and laying them: (*a*) Size and shape of stone; (*b*) quality of sand; (*c*) condition of cement; (*d*) manner of mixing; (*e*) manner of putting in place.

2. What preparations do the masons make for the setting of iron beams?

3. Describe the process of setting a heavy support and massive brick pier, capable of supporting very heavy loads: (*a*) Dressing of the stone; (*b*) laying the mortar; (*c*) placing the stone; (*d*) how can you tell if the stone is solidly bedded? (*e*) what should be done to prepare the top of the pier and the bed of the stone before the mortar is used?

4. Where an iron girder is used instead of a wall to support the ends of wooden floor beams, what mason work does the law require?

5. If piles should be driven without reaching solid bottom, how would you know whether they were able to support the wall above?

6. Why is it important to see that a footing is no narrower and no wider than the plans call for?

7. Is it dangerous to make a footing too wide? If so, why?

8. If a concrete footing were made too wide for safety, how might it easily be made safe?

9. Suppose an excavation were to be dug below the footings of an adjoining building. State fully what is required in such cases in the way of protection and new work.

10. What peculiarity is required for mortar of foundation walls which is not needed above ground?

11. Name three ways of securing face-brick to the backing.

12. Describe the arrangement of floor beams about a chimney-breast: (*a*) Location of header; (*b*) location of trimmer; (*c*) how are the beams to be framed together? (*d*) what size should the header and trimmer be?

13. Suppose a white pine post of moderate height to be used temporarily for the support of a load, what load would you consider it safe to apply per square inch of its cross-section?

Arithmetic.

1. Add 18 ft. 8 in.; 24 ft. 11 in.; 13 ft. 7 in.; 17 ft. 5 in.; 34 ft. 6 in.; 19 ft. 11 in.

2. Subtract 189 ft. 9 in. from 304 ft. 3 in.

3. Multiply 12 ft. 9 in. by 319 ft.

4. If a floor 125 ft. 5 in. long is covered with tiles, each 9 in. long, how many tiles are there in a line?

5. Find the cubical contents of a wall 310 ft. 7 in. long, 10 ft. high, and 12 ft. 8 in. broad.

BUILDING INSPECTOR—MASONRY AND CARPENTRY.

Oral.

Note: The oral examination consists of the following questions in reference to diagrams placed before the applicant:

1. What is the extreme depth of this foundation below the curb? (See foundation.)

2. What is the width of concrete at base at front of area inside of curb?

3. How are the wall columns at the sides of the building supported at the base? (See cross-section—rear elevation.)

4. What are small white squares in the sidewalks? (See floor plans.)

5. What are the two larger white openings shown in plans near right front corner. (Vents.)

6. What are the partitions around elevators and stairs constructed of?

7. Point out the different materials and name them.

8. What is this a drawing of? (Blue-print of cantilever.)

9. Which of the columns supports the side wall?

10. Describe the centre columns in rear wall of the tenth story of this building.

INSPECTOR OF MASONRY AND CARPENTRY.

APRIL 14TH, 1904.

1. (*a*) What is a curtain wall? (*b*) Explain requirements of the section of the Building Code which refers to same.

2. (*a*) What is a row-lock arch? (*b*) Explain the differences from other arches. (*c*) Is it as strong? Give reasons.

3. (*a*) Why are floor beams beveled? (*b*) How much are they beveled? (*c*) How often are they anchored to walls?

4. Describe the methods of protecting iron columns against fire.

5. Describe two systems of fireproof floors.

6. (*a*) Describe system of fireproof furring. (*b*) Explain method of application.

7. When piles or timbers are used for foundations, what important requirements are to be observed?

8. (*a*) What is dry-rot? (*b*) What precaution should be taken against it? (*c*) How can it be remedied?

9. In case floor beams are overloaded in a building under construction, has the inspector any duties, and what are they?

10. What are inverted arches; when and how are they used?

11. Suppose an excavation shows a steep rock, what is to be done in reference to foundation?

12. What is a trimmer arch? Should centering be removed after arch is built? Give explanation.

13. (*a*) What are the general defects of lumber, and how do they impair the strength of the material? (*b*) If a beam has a loose knot on one side, should it be placed on upper or lower side of beam?

MATHEMATICS.

1. Addition: $1\frac{1}{3}$, 0.005, 17/19, 1.45.

2. Division: 0.4934 by 0.00456.

3. Calculate number of cubic feet in a wall of given dimensions.

4. Compute area of a wall of given dimensions?

Oral Examination.—Questions on plans of a model building, iron construction, quality of lumber, quality of stone.

INSPECTOR OF MASONRY.

1. Where granite is to be used for a massive wall or a dam, how would you inspect the stone as to its quality in everything which may affect the durability or its power to bear loads, and what would you look for?

2. What defects would you look for (in stone for the same uses) in (*a*) limestone, (*b*) sandstone?

3. State the differences between (*a*) good and poor brick, and how they are examined; (*b*) the same for sand.

4. (*a*) Having no testing machine, state how you can satisfy yourself that a barrel of cement is in good condition and safe to use. (*b*) How would you place cement in barrels where no sheds are available, so as to prevent probable damage?

5. (*a*) Suppose that in excavating for the foundation of a wall to carry a heavy load, a ledge of rock is struck, what examination would you make? (*b*) Suppose the rock to be steeply inclined, what would you require before starting the wall?

6. Suppose a wall is to be founded on earth and the excavating is completed. What would you do in preparation before placing anything upon the earth?

7. Can concrete for a foundation be placed in water where to do otherwise would be very difficult, and if so, how is it done and what precautions are taken?

8. Describe clearly the different kinds of (*a*) rubble masonry; (*b*) ashlar work; (*c*) six-cut work.

9. (*a*) For the strongest and tightest work, what thickness of bed-joint do you think best? Give reasons for your opinion.

10. To get the best adhesion of cement to stone, and the tightest work, what are the essential things to be attended to in laying the stone?

11. How are the very thin joints made in laying up fine cut stones in the fronts of buildings?

12. When the beds of stones only are pitched true, and joints half an inch are provided for, describe the operation of setting the stones in such a way that you are certain to fill all space in the beds with mortar?

13. Describe the face bond you would require in heavy stone-work courses one to two feet thick, particularly as to horizontal distance between vertical joints in adjacent courses?

14. Where the stones in such a job are cut full to dimensions at the back as well as at the front, how would you fill the vertical joints to get the best job, supposing them to be about ½ in. thick?

INSPECTOR OF MASONRY.

1. Suppose you were at work with no opportunity of reaching a testing machine, and you had to decide whether the cement furnished was fit for use, state every test you could make, and why you would make it.

2. Suppose a cement to be in good order, state two important characteristics which affect its strength, and its durability.

3. The proportions of the cement, sand, and gravel to be used being given, describe the very best method of mixing them into concrete.

4. Give all the reasons why it is improper to dress or trim stone on a wall which is being constructed.

5. (*a*) Why can you not lay stone satisfactorily when it is raining? (*b*) What is the effect of trying to set a stone which is frosted?

6. If obliged to set stone in freezing weather, state everything that can be done to obtain reasonably good work.

7. When concrete in considerable amount is to be used in important works, and it is desirable to get the most solid and impermeable job, state every precaution to be taken in every part of the work (except for mixing), including subsequent care and treatment, until it is set hard.

8. In setting a massive stone (weighing 10 tons) with rough beds, state everything you would do to secure impervious joints, and the best possible adhesion of the mortar to the stone.

9. Understanding the term grout to mean a mixture of cement or cement and sand mixed thin enough to run freely, what do you think of its use in filling the joints of masonry? If there are any objections to its use, what are they?

10. Where an important dam is to be built of rubble masonry, describe in a general way the bonding of the stone to make the strongest and tightest dam.

11. (*a*) When a heavy wall is to be built and the trench is dug, how would you examine the bottom before starting the work? (*b*) How might the examination affect the subsequent work?

12. Show or describe three ways of taking hold of a stone to hoist it.

13. Describe (*a*) what is called rock-faced masonry; (*b*) pointed work; (*c*) six-cut work; (*d*) what is meant by scabbing?

14. Describe (*a*) pean hammer and its use; (*b*) bush hammer and its use.

15. Describe how improper work is done in (*a*) six-cut work; (*b*) pointed work.

INSPECTOR OF STEEL.

SALARY, $1,200. JANUARY 9, 1904.

1. (*a*) Describe the difference in the appearance of fractures of good steel and of good cast-iron. (*b*) Also how both differ from that of good wrought iron.

2. Describe the appearance of each of the above when the material is poor.

3. State what a drift pin is for, and whether it has any effect upon the strength of the material in which it is used, and what that effect is.

4. (*a*) Describe carefully the whole operation of driving a rivet properly, beginning with the heating. (*b*) Describe every way in which improper work is done in driving a rivet. (*c*) State how you would test a lot of riveted work.

5. (*a*) Describe the proper way of testing thoroughly the thickness of a cast-iron column. (*b*) Describe carefully the method of testing the soundness of a cast-iron column. (*c*) What parts of a cast-iron column require special care in examination to prevent accident?

6. (*a*) Suppose a cast-iron column to be ½ in. too short, what would you do? (*b*) Suppose such a column to have one of the ends not turned square, what would you do?

7. (*a*) Make pencil or pen sketches of a wrought iron column in front of a building showing front and side views, giving clearly the details for the support of the wall, say in the second story. (*b*) Show clearly also the method of splicing such a column.

8. Where, in a detail drawing, a number of small circles are shown at some parts all filled in with hatching, or entirely black, what does it mean?

9. In setting the iron base of a large column on a masonry foundation, what is the very best way of doing it to secure a thorough bearing?

10. As you know, in building very high buildings, it is customary to run the iron work up and store large quantities of material upon the floors during construction. Are floors overloaded in this way, and if so, what would cause you to think so?

11. Would you consider it necessary to make any inspection of girders, posts or other iron work, after delivery on the ground before erection? If so, state exactly and fully what that inspection should be.

12. Suppose that during erection certain rivet holes do not come "fair": (*a*) What might it indicate in the case of a floor beam? (*b*) How should such errors of every kind be corrected?

13. Is there any difference in the strength of riveting done in the shops and on the work? If so, which is the stronger and why?

14. (*a*) Where bolts are to be used permanently in a piece of work, how is the strongest job obtained? (*b*) Which is the stronger, bolting or riveting, and why?

15. Are any precautions against wind ever necessary in the erection of ironwork in a building, and if so, what?

Mathematics.

1-2. A bar of iron 3 ft. long and 1 in. square weighs about 10 lb. and steel weighs 2% more. Assuming this, calculate the weight of a plate girder 25 ft. long and 30 in. deep, which is made up of a web plate $\frac{1}{4}$ in. thick, 2 cover plates each 8 in. wide and $\frac{3}{8}$ in. thick, four angles each weighing 8 lb. per ft., and, say (including ends and intermediates) 12 vertical stiffeners weighing 5 lb. per ft.

3. A brick wall resting on a girder measures 18 ft. long, 13 ft. 6 in. high and 15 in. thick. In it there is a window 9 ft. 6 in. high and 6 ft. 3 in. wide. Assuming brickwork to weigh 115 lb. per cu. ft., what load does the girder sustain?

4. The iron beams in a warehouse floor span 16 ft. and each weighs 40 lb. per ft. The spans between the beams are 5 ft. 6 in. The arches weigh 40 lb. per sq. ft., and a load of 270 lb. per sq. ft. in addition is to be provided for. What is the total load on one floor beam?

5. Add 3 ft. $7\frac{1}{2}$ in., 9 ft. $2\frac{1}{4}$ in., 12 ft. $9\frac{1}{8}$ in., 27 ft., 42 in., 14 ft. $11\frac{3}{8}$ in.

INSPECTOR OF STEEL CONSTRUCTION.

TECHNICAL.

FEBRUARY 15, 1906.

1. In the storing of structural steel on the ground prior to erection, what general rules should be observed?

2. In the handling of structural steel, unloading, storing or assembling, what must be carefully guarded against?

3. State what you would do if in assembling you found a member bent or otherwise injured.

4. Describe an erection sheet and state how you would use it.

5. (*a*) What is falsework? (*b*) What is it used for in bridge work? (*c*) Is falsework employed in the erection of all bridges? (*d*) Where falsework is being used, and a considerable part of the bridge has been assembled on it, what particular feature of the falsework would you carefully inspect, and how often would you make the inspection?

6. Describe in detail the usual order of assembling the parts of a "through truss" riveted highway bridge.

7. In assembling bridge members in the structure, is it permissible where connections are "tight fits" to use force to properly enter the members, and, if it is, how should the force be applied?

8. What must be particularly noted in assembling connections regarding the surfaces which become inaccessible after assembly?

9. How should large steel pins be driven in connections and how should they be protected?

10. What do you understand by the term "fitting up" as applied to a connection to be riveted? State briefly the matters which should receive careful attention in "fitting up."

11. What is (*a*) the legitimate use of a drift-pin in fitting up? (*b*) Is the use of a drift-pin allowable in bringing holes to match?

12. In "fitting up" an important connection, what proportion of open holes should be filled up and how?

13. In the splicing of chords, what distinction would you make in fitting up (*a*) splices in compression and (*b*) splices in tension?

14. At a connection fitted up for riveting if the holes do not match how should the defect be remedied? How much of a misfit of

rivet holes may be properly allowed without ordering new plates for the splices or connection?

15. (*a*) Name in the order of their efficiency in securing tight rivets the three principal methods of driving rivets. (*b*) What are the main objects to be attained in driving rivets to secure good work?

16. (*a*) Describe the methods by which "field" rivets are generally heated. (*b*) To what extent should they be heated? (*c*) How should they be heated to produce good work? (*d*) How would you determine if a rivet was "burnt"? (*e*) Would you permit the use of a rivet that has been reheated several times? (*f*) What should be done with a rivet that "sparks" or "spits" on being taken from the fire? (*g*) Should a rivet be worked after it has become black?

17. Name and briefly describe the tools used in field riveting.

18. How would you determine when a rivet was tight? (Answer this question in detail, describing step by step the necessary procedure).

19. Describe the common "scamp" methods employed to make loose rivets appear tight. (*b*) How would you detect rivets that had been tightened? (*c*) How would you mark defective rivets and how are such removed from the work?

20. Name the different styles of rivet heads.

21. If a bridge is being erected on falsework, when and how may a span be swung?

22. (*a*) What should be the condition of the surface of steel when paint is applied? (*b*) What are the usual methods of cleaning steel preparatory to painting? (*c*) What should be the condition of the weather when paint is applied to steel?

23. Under what circumstances, if any, may paint which has been delivered at the work be "thinned"? If so, when and how should it be thinned?

24. (*a*) State clearly and fully with what bridge and structural work you have been connected and in what capacity. (*b*) Give your experience in detail under the following heads:

(*a*) Shop experience. (*b*) Field experience.

Arithmetic.

1. Find the sum of (*a*) 11 plus 135 plus 78 plus 112 plus 33. (*b*) \$1817.36 plus \$3114.65 plus \$472.19 plus \$5.15 plus \$9542.37.

2. (*a*) Find the difference between 4912 and 2615. (*b*) On a certain day there were 165 rivets to be driven—on the following day 60 were driven and 45 on the next. How many were left to be driven?

3. (*a*) Find the produce of $23 \times 45 \times 7$. (*b*) If 8 men can do a piece of work in 7 days, how long will it take 2 men to do it?

4. (*a*) Find the quotient of 347802 divided by 9. (*b*) At two cents per pound, how many pounds of iron can be bought for $93.33?

5. What is the difference between one inch and one-tenth of a foot? (*b*) Change $1\frac{3}{8}$ inches to the decimal of a foot.

Report.

Write a typical form of a weekly report showing the progress of the work, material received, placed and condemned.

INSPECTOR OF REGULATING, GRADING AND PAVING.

1. State what you understand by the term "regulating."

2. Where a high embankment is to be made in grading a street state (*a*) whether it makes any difference how the material is distributed, and if so, what the rule is. (*b*) Give your reasons.

3. State fully and clearly everything to be done in preparing the ground surface for and laying a telford road, all but the last four inches—that is, all but the finishing courses.

4. What do you understand to be the difference between materials classified as rock and those classified as earth in paying for grading jobs? How is the classification determined?

5. Describe in your own language a perfect paving block, considering (*a*) its form, finish and dimensions; (*b*) the materials of which it is composed and its physical condition.

6. Is it detrimental, in your opinion, to pave stones of different depth in the same row in a pavement, and if so, why?

7. In what ways is poor work done by pavers in selecting and placing paving blocks?

8. What is meant by "back ramming" and what is its object?

9. (*a*) Draw lines representing a street intersection and show the proper way of placing paving blocks at that point. (*b*) State why it is the best way.

10. (*a*) State how you can tell whether the paving pitch has been overheated or not. (*b*) What is the result of overheating on its wearing qualities?

11. (*a*) What is the proper temperature at which asphalt should be brought on the work? (*b*) What effects are produced by its being either too hot or too cold? State each.

12. Which would you consider the best finish to leave on the surface of a concrete bed for an asphalt pavement—that it should be smooth or left rough? State your reasons.

13. (*a*) In preparation of the surface of cement to receive binder, or of binder to receive a subsequent coat of asphalt, name two essential things to be guarded against. (*b*) State why.

14. How may water affect a pavement after it is laid, and where is this effect most likely to occur? (*b*) What is done to prevent this?

15. State as nearly as you can the causes for (*a*) the formation of long cracks across an asphalt street. (*b*) The shoving up into waves. (*c*) The breaking up or wear in spots.

Report.

You are sent to inspect where the pavement has been relaid after having been torn up by a railroad company. Assuming such facts as you please, write a report of your inspection of not less than a page, properly made out, and signed with your examination NUMBER and NOT your name.

Arithmetic.

1. Add 357$\frac{1}{4}$, \$4,078.09, \$.18, \$769$\frac{3}{4}$, \$.37$\frac{1}{2}$, \$86.88, \$450 and \$.095.

2. Take 3,907,482 from 8,600,401.

3. Multiply 9,048 by 605.

4. Divide 548,130 by 906.

5. Find the number of cubic yards in a ditch 4 ft. 6 in. deep, 5 ft. wide and 7 ft. 8 in. long.

INSPECTOR OF SEWER CONSTRUCTION, 4TH GRADE.

1. What are the essential requirements in a well-constructed sewer?

2. Suppose the top of the grade stake set at one end of a 25-ft. length of sewer was 13 ft. 3 in. above grade, and at the other end 11 ft. 7 in. above grade; how would you fix your grade line?

3. Where are headers used in a circular brick sewer and why are they so used?

4. (*a*) Is an arch centre a full semi-circle? Show by sketch the construction of a centre, and how it is supported and lowered.

5. Describe the proper method of keying a brick arch.

6. It is necessary to rebuild 100 ft. of a 48-in. brick sewer with considerable flow of water through it; describe completely the operation.

7. How much clearance in a trench should be allowed each side of a sewer to obtain good work?

8. Describe (*a*) your inspection of bricks delivered on the work for a sewer; and (*b*) the only right way of laying the same to insure tight work.

9. Under what conditions would you think it desirable to leave the sheeting in a trench, and why?

10. What are the rules governing the insertion of spurs in brick sewers, as to location, direction, etc.?

11. Describe the rules that must now be observed in laying pipe sewers.

12. How soon can filling in be done about a pipe sewer? What governs this?

13. Describe a good job of tamping earth around a sewer, giving best arrangement of men, and other requirements.

14. What is the best way of controlling quicksand where it is met with in an excavation?

15. (*a*) What is the diameter of the largest vitrified sewer pipe in use in the city? What is the diameter of the smallest brick sewers now built in the city?

Arithmetic.

Give all the figuring on the ruled sheets.

1. Add

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7365867
2345678
9876543
2154672
7658899
5342544
2534353
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2. Subtract 290987 from 320045.

3. Multiply 78096 by 4097.

4. Divide 2601024 by 4278.

5-6. How many cubic yards of earth are required to fill a trench 104 ft. long, 8 ft. high, 6 ft. broad at the bottom and 12 ft. broad at the top?

Report.

Write a weekly report of at least two pages on the construction of a 6-ft. outlet sewer in bad ground. Give such items as you think should appear, including all difficulties met with during the week.

N. B.—Sign this report with your examination number and not your name.

Experience.

1. What is your age?

2. (*a*) Have you served an apprenticeship as a mason? (*b*) If so, state length of service and when it terminated.

3. Have you had experience as a foreman? If so, state in full such experience, giving dates and location.

4. Have you served as an Inspector? If so, give full details of this experience.

NOTE.—Confusion or omission of dates and incompleteness of statement count against the candidate.

5. Give the names and addresses of two persons to whom reference may be made for verification of the above statements.

INSPECTOR OF SEWERS AND SEWER CONSTRUCTION.

TECHNICAL.

1. (*a*) Describe the way in which you would examine the quality of sand on the work. (*b*) Describe the same as to whether the cement is in good condition. (*c*) Describe the test you would apply to bricks for sewer work.

2. Describe carefully the proper way of caring for the cement delivered on a work to keep it from injury.

3. (*a*) How much wider should the trench for a sewer be than the outside diameter of sewer, in other words, how much space should there be? (*b*) What is the reason for this?

4. Suppose the elevation given at one end of a 25-ft. length of sewer to be 12 ft. 3 in. above grade and at the other end to be 11 ft. 9 in., how would you fix your line so as to give correct grade at any point in that portion of the sewer?

5. Having correct grade, describe operation of preparing for and properly building the invert of a sewer.

6. Describe the bond adopted in this part of the work?

7. Are headers used in bonding the course in sewer work, and if so, how often and why?

8. Is there any reason for not using headers, and if so, what is it?

9. Describe the complete operation of properly laying a brick in a sewer, giving every detail.

10. Suppose a manhole is to be built at the intersection of a 2-ft. sewer with a 4-ft. sewer, at what elevation should the small sewer enter the large and for what reason?

11. When a sewer is to be laid through very wet ground, is any special watchfulness required of the inspector, and if so, what?

12. What is the rule as to leaving off work on a brick sewer? Should the end be left "toothed" or "racked back," and for what reason?

13. Describe all the requirements in the proper refilling of a trench after a sewer has been built.

14. State every item that sewer inspectors should note and report on regularly.

INSPECTOR OF SEWER CONNECTIONS.

Technical.

1. At what height must a sewer connection be inserted in a brick sewer? Why do you think this necessary?

2. How often are spur connections made with sewers?

3. In inserting a spur in a brick sewer, is there any rule as to its direction and the method of finishing the work, and if so, what is it?

4. What size is the regular spur for house draining?

5. How many houses are allowed to drain into one spur?

6. Are larger spurs allowed, and if so, under what rule?

7. Does the Inspector of Connections have any authority over the laying of the house sewer in the street? If so, what? Where does his authority end?

8. What report as an Inspector would you make? Give the items.

9. How are the house connections located so that they can be found again?

10. Would you think it your duty to take any notice of the condition of a sewer, or of the pavement?

11. Give any other details as to your duties which are not called for by the previous questions.

Arithmetic.

1. Add 1234562; 9876; 278349; 968; 7865; 2678394; 2738492.

2. Subtract 367842 from 478096.

3. Multiply 76954 by 4097.

4. Divide 1676044 by 2347.

MANUAL OF EXAMINATIONS

FOR

ENGINEERING POSITIONS

IN THE

SERVICE OF THE CITY OF NEW YORK

INSPECTOR

TYPICAL QUESTIONS AND ANSWERS

TYPICAL QUESTIONS AND ANSWERS.

INSPECTOR—BUILDINGS, MASONRY, CARPENTRY, ETC.

1. What are the duties and requirements of an Inspector on public work?

1. The Inspector should understand the plans and specifications of the work under his charge.
2. He should see that all material used and work done is in conformity with same.
3. He must be a good judge of materials and workmanship.
4. He should be punctual and steady on the work.
5. Keep correct, careful and complete records of forces employed, material delivered, rate of progress, etc.
6. To keep records of work condemned, materials rejected and reasons therefor.
7. To see that no rejected material goes into the work.
8. To follow the instructions and wishes of his superior.
9. To notify his superior of infractions of rules, poor work, errors or other difficulties.
10. To preserve marks set by Engineer until no longer needed.
11. To assist Engineers or Foremen in giving line and grade.
12. He should be tactful, determined and just; protect the interests of his employer and secure as good and as rapid work as he can.

2. What precautions must be taken regarding excavations?

All excavations must be properly guarded and protected so as to prevent the same from becoming dangerous to life. They shall also be sheeted where necessary to prevent adjoining earth from caving in. Where excavations are made to 10 feet or more below the curb the walls of adjoining property must be shored and preserved, without injury to same.

3. When a trench for a wall has been made to the right depth in any kind of earth, what is the next step?

In earth, objectionable material should be removed and replaced with concrete, sand or good, firm earth. The bottom of the trench is leveled off to an even surface, flushed and rammed. The footing courses are then laid. In rock, the bottom is cleaned, stripped of disintegrated portions and stepped off. The masonry is then started.

4. How would you prepare the foundation for a heavy wall and how deep should it be excavated?

The foundation for a heavy wall should be excavated about 3 ft., and more if required by the character of the material, or if very heavy loads are to be carried.

After excavation, the foundation should be freed from all foreign and decayed matter, the hollows and poor portions being replaced by good, firm soil or concrete. The bottom must be thoroughly wetted and compacted before the masonry is started. The trenches should be kept dry by pumping if necessary and any springs or fissures plugged up. If rock is encountered in the foundation it should be stripped of loose or decayed portions and benched or stepped, if too smooth. Before masonry is started the surface should be well flushed.

5. Would a sandy bottom be good to start a foundation on?

Sand, when confined so as to be kept from flowing, makes a good foundation.

6. Give the safe bearing power of gravel, good clean sand, loam, clay, hardpan, rock.

Gravel	5	tons	per	sq.	ft.
Good, clean sand	4	"	"	"	"
Loam	1	"	"	"	"
Dry clay	3	"	"	"	"
Wet clay	2	"	"	"	"
Hardpan	8	"	"	"	"
Rock in ledges	36	"	"	"	"
Rock in beds	240	"	"	"	"

7. Describe the kind of foundations best suited to the following soils:

(*a*) Stiff gravel.
(*b*) Wet, soft mud, becoming stiffer as depth increases.
(*c*) Soft mud with hard gravel 15 ft. beneath.
(*d*) Wet, but confined and compact sand.

(*a*) Excavate to the required depth; smooth the bottom and over it spread a layer of concrete to form the foundation.

(*b*) Drive piles to proper bearing, cut the piles off level, build a timber grillage platform and place concrete upon it. Or cap the piles and surround with concrete.

(*c*) Build a coffer-dam, or sheath the outside of foundation area; excavate the mud, prepare the bottom and deposit concrete. Or proceed as in case of soft mud (*b*).

(*d*) Deposit concrete on the prepared bed of sand previously drained.

8. Bulk in place being assumed at 100, what would be the shrinkage in embankment for: loam, dry; loam, wet; loam, rolled; soft clay; stiff clay; sand; gravel?

The shrinkages in the embankments usually allowed for are—

For Loam, dry	12%
Loam, wet	10%
Loam, rolled	15%
Clay, soft	8%
Clay, stiff	10%
Sand	9%
Gravel	8%

9. How are walls founded on soft or yielding materials?

The material is excavated for two or more feet and piles driven to firm bearing. These piles are cut off at the same elevation, capped and a foundation bed of concrete deposited in the excavation or upon a platform erected on the piles. Upon this concrete the wall is built.

If the depth of the soft material is not very great the trench for the wall may be excavated to a hard bottom, and the excavation refilled with concrete which forms the foundation bed.

The area of the foundation bed may be increased by grillage construction so that even in somewhat yielding material sufficient area may be secured to make the wall safe.

10. When water is being pumped from the soil in the excavation, how would you determine whether it is endangering surrounding buildings?

Examine the water discharged by the pumps, and note whether it is clear or contains material from the building foundations adjacent to the excavation. If the water is continually charged with this material, the foundations may be endangered.

11. What should be done if the soil under a certain footing were found to be softer than allowed for?

The excavation should be carried down to firmer soil, and the spread of the footings increased.

12. If it were found necessary to increase the area of the bottom
excavate the mud, prepare the bottom and deposit concrete. Or pro-
be altered, and if so, how?

Underpin the pier, excavate under the footing, and put in the additional footings to obtain the required area.

13. Who is responsible for the safety of buildings adjoining an excavation?

Usually the contractor. The owner of the adjoining building whose wall does not extend to a depth of 10 feet below the curb is required to protect his building at his own expense, but if the excavation extends over 10 feet below the curb, then the party making the excavation must do all underpinning, etc., and leave the adjoining walls practically as safe as they were before.

14. What methods and precautions are necessary in excavating rock, including blasting, in vicinity of houses, and what when water-pipes are present?

The contractor should comply with all ordinances of the city. Before a blast is fired the rock should be covered with mats and logs. The prescribed explosives should be used in small charges.

In residential districts blasts should not be fired between 8 P. M. and 7 A. M. No more explosive than is needed for 12 hours should be stored at one time on the work. It should be divided as much as possible, kept under lock and key, and separated from caps and exploders. Rock within 5 ft. of water-pipes should be removed by hand.

15. Discuss briefly the methods of handling quicksand in construction.

The methods commonly employed to handle quicksand are:

1. By sheeting and bracing. The excavation should be made several feet wider than necessary allowing space for heavy sheeting. Above the quicksand the sheeting may be of the ordinary type, but extra heavy and firm. The sides of the excavation through the quicksand should be protected by double-wall sheeting—constructed of two rows of timber filled with clay, and provided with a cutting edge at the bottom to assist in sinking. As the lining is sunk the core is excavated.

2. By solidifying the quicksand with grout or cement. Pipes are sunk and grout or cement powder forced into the quicksand under pressure, forming a mortar or concrete. By regulating the depths of the pipe any required mass can be solidified.

3. By the freezing process. A series of pipes 10 inches in diameter are sunk in a circle through the overlying earth. Eight-inch pipes, closed at the bottom, are sunk inside the 10-in., and smaller pipes open at bottom are placed in the 8-in. pipes. A freezing mix-

ture is then forced through one set of pipes, returning by the other, thus solidifying the surrounding mass of quicksand, which can then be removed in the usual way.

16. Suppose a dam is to be founded on rock, and on uncovering the rock it is found to be seamy, with water coming up at points; what would you do? Suppose there is a spring with considerable head, what can be done?

1. Remove the disintegrated portion of the rock, and pack quick-setting neat cement or a rich mortar in the seams (previously enlarged for the purpose), or, if necessary, pump grout into the seam until the flow is stopped.

2. In the second case, tap the spring and lead it away through an iron pipe to the down-stream side of the dam; or, tap the spring with an iron pipe, carrying the latter up vertically with the masonry until the water rises no higher. If possible, the spring should then be drained by pumping, and grout should be forced in under pressure to seal it.

17. What precautions are to be taken for the health of assistants or laborers working under pneumatic pressure at a depth of 75 ft.?

Proper ventilation should be maintained. Carbonic acid gas not to exceed one-tenth of 1%. Noise-deadening devices should be used. Fumes from blasts must be rapidly removed. Ample locks of approved pattern must be provided. Suitable quarters should be provided near the shaft where men can wash, bathe, change clothing, and be warmed on coming out of compressed air. Hot coffee should be obtainable at all times, and a physician must be in attendance. A compressed-air hospital lock should be provided in case men are attacked by caisson disease.

18. What must be the size of piles for foundations and how spaced?

Piles for walls, piers, etc., must be at least 5 in. in diameter at the small end, 10 in. at the butt-end, spaced 30 in. apart or more, and driven to a solid bearing.

19. What load may be placed upon a pile?

No pile shall take more than forty thousand pounds.

20. What effect, if any, has the brooming of a pile upon the effect of the hammer in driving it?

A "broomed" head acts as a cushion and dissipates the blow of the hammer.

21. Outline briefly the essential points to be covered in specifications for timber piles and pile driving.

The specifications should describe the kind of timber, such as oak, pine, etc. The pile shall be not less than 8 in. nor more than 12 in. at small end, and not less than 12 in. at large end. The timber shall be free from shakes and defects. The piles shall be pointed before driving. They shall be straight, and bark removed. Only portions left in work will be paid for. The top shall be banded before driving. The broomed portions shall be cut off. Iron shoes must be provided if necessary. The weight and fall of hammer and the penetration due to last blows shall be specified.

22. Describe briefly the several methods of sinking wooden piles and the conditions under which each would be used?

Wooden piles may be sunk:

1. By the ordinary pile-driver. An iron hammer weighing one to four thousand pounds is raised by machinery and permitted to fall upon the head of the pile. Used under almost all conditions.

2. By the steam hammer. In this case the hammer is operated by steam, permitting the blows to follow very rapidly. Adapted to all conditions, especially in quicksands and soft soils.

3. By the water jet. An iron pipe is fastened to the side of the pile and lowered with it, the lower end of the pipe being near the point of the pile. Water is forced into the pipe causing a softening and loosening of the material below the point of the pile. The pile is forced into the material by the weight of the hammer resting upon it and by blows when necessary.

4. Piles may also be driven by utilizing the explosive force of gunpowder or dynamite, suitable apparatus being provided.

23. In driving piles through quicksand, which is the most effective method, a succession of quick, light blows or of slow, heavy ones? Give your reasons.

Quick, light blows are the most effective. The quicksand runs freely and tends to force the pile up. Quick, light blows will prevent this, and also prevent the sand from settling about the surface of the pile which increases the resistance to driving.

24. Describe the various ways of shaping and using sheet piling to keep water from work in progress.

The sheet piles may be—
1. Tongued and grooved.
2. Overlapping.
3. Grooved only, with tongues driven in the grooves.

The ends of piles should be sharpened to facilitate driving.

Two rows of guide piles are first driven about 10 ft. apart. A pair of waling pieces are then fastened to the guide piles near their top leaving a space between waling pieces equal to thickness of the sheet piles. The sheet piles should be driven between the wales, starting at each guide pile working towards the center, the center pile forming a wedge to tighten the row. The point of the pile being driven should bear against the adjacent pile.

25. (*a*) When is sheet piling left in? (*b*) When is it tongued and grooved?

(*a*) When careful drawing of same is apt to disturb retained material and thus endanger the foundations of adjacent structures. Also when the cost of drawing same is greater than the value of the timber.

(*b*) Sheeting is tongued and grooved when driven in water-bearing material to keep out water or freely-flowing sand, mud, etc. It is tongued and grooved for coffer-dams, caissons, etc., to make water-tight compartments.

26. Name the common kinds of wood used in building and state the purpose for which each is used.

Ash—Used for interior and cabinet work.
Cedar—Used for posts, ties and fences.
Cypress—Used for interior work.
Elm—Used for ties and bridge timber.
Hemlock—Used for rough lumber for construction.
Locust—Used for fence posts and ties.
Maple—Used for interior work.
Oak—Used for ties, posts and where strength is required.
Palmetto—Used for under-water construction.
Pine, red yellow, white—Used for all construction purposes.
Spruce—Used for piles and construction purposes.
Walnut—Used for interior work.

NOTE.—For complete table of properties of woods see Byrne's "Inspector's Pocketbook," p. 56.

27. Under what conditions can wood be used in permanent construction?

It can be used for work under water. It must not be exposed to the air at any time. It must also be protected from the teredo or other destructive insects present in water.

28. What kind of timber resists decay longest under ground? Under water?

Under ground—Cedar, locust, chestnut, oak.
Under water—Florida palmetto.

29. What is the best method of preserving piles in sea-water? In the ground?

In sea-water piles are best preserved by the creosoting process.

In the ground impregnation with creosote or with chloride of zinc are considered the best methods.

When piles are exposed to tide-water they should be driven with the bark on, spruce or hemlock being commonly used. Where the teredo is active, Florida palmetto gives good results.

In firm soils, pines, oaks, elms or firs are used, the bark being removed.

30. How may timber be preserved from decay?

There are several methods in use for the preservation of timber:

1. Burnettizing or impregnation of the timber with chloride of zinc.
2. Impregnation with copper or zinc sulphate.
3. Kyanizing—Impregnation with bichloride of mercury.
4. Creosoting—Impregnation with creosote or dead oil of coal tar.

In all these cases the timber is heated, the sap vaporized, the air exhausted from the pores by means of a pump and the preservative forced into the pores under pressure.

5. Vulcanizing—In this case the wood is heated while under air pressure. The operation renders the sap insoluble and the timber durable.

31. How would you prevent dry rot in floor beams?

Use seasoned dry wood for the beams. Have the open spaces ventilated; treat the wood with coal tar or some other approved process.

32. What is hydraulic cement, and how many kinds do you know of? What is the essential difference in their manufacture?

Cement which possesses the property of setting under water is called hydraulic cement.

There are three varieties of hydraulic cement: Portland cement, Rosendale or natural cement, and Puzzolana.

Portland is made of an artificial mixture of the ingredients, ground, roasted and powdered.

Rosendale is prepared by roasting and powdering the natural cement stone.

Puzzolana does not require any roasting, but is prepared by simply powdering the natural rock.

33. What are the physical differences between American Portland and Rosendale cements? How are they manufactured?

Physical Differences.

Portland Cement.	*Rosendale Cement.*
Texture—Close, floury	Porous and globular.
Color—Bluish and greenish gray	Brownish.
Slower setting than Rosendale	Sets quickly in air. Hardens slowly in water.
Spec. Gr., 3.0±	Spec. Gr., 2.7±.
Weight, 86± lb. per cu. ft.	Weight, 50± lb. per cu. ft.
Stronger than Rosendale	Not as strong as Portland.

In the manufacture of Portland cement, lime rock and cement rock are quarried separately, ground, mixed and then roasted. The clinker is then crushed and pulverized, and bagged for the market.

Rosendale cements are manufactured in a similar manner, only that the raw material is natural stone, containing proper proportions of the ingredients.

34. What is the meaning of the term "setting" as applied to cement?

Setting refers to the process of chemical combination which takes place among the particles of cement when subjected to the action of water, resulting in its hardening.

35. Does the quality of cement, particularly Portland cement for hydraulic work, depend in any way upon its storage? (*a*) If so, state how it is affected by storage? (*b*) State what may be the after-effect upon a structure of lack of care in this respect. (*c*) Describe the proper storage of cement.

Yes.

a. Fresh cement has a certain amount of free lime which is removed by exposure to the air; fresh cement not having time to cool "swells" or "blows."

b. Lack of care in this respect causes swelling of the lime, which may be followed by breaking up of the masonry, thus endangering the structure.

c. Cement should be stored in a dry enclosure, upon a platform raised a few inches above ground. It should be protected from rain or moisture by suitable covering.

36. Describe, as far as you know them, the tests for cements where great strength is required?

The tests for cement are:

1. Test for fineness of grinding.
2. Test for specific gravity.
3. Test for time of setting.
4. Test for soundness.
5. Test for strength.

1. The test for fineness is made by passing the cement through sieves of various meshes and noting the percentages retained in each. Not more than 2% should be retained on a No. 100 sieve, and 10% on a No. 50.

2. Specific gravity of cement is determined by using a special specific gravity balance. The specific gravity should be about 3.1.

3. Time of setting—activity.

Pats of cement are made with about 25% water, 2 or 3 in. in diameter, and $\frac{1}{2}$ in. thick. They are immersed in water at 65° F., and the time required to set hard enough to bear $\frac{1}{12}$-in. wire having a $\frac{1}{4}$-lb. weight, and $\frac{1}{24}$-in. wire having a 1-lb. weight, is noted, giving "initial set" and "final set." For a good cement the time for the initial set should be less than 45 minutes and the final set within 10 hours.

4. Soundness is determined by immersing the pats made with thin edges in water and noting blowing or cracks at edges, which indicate free lime or magnesia. If lime is present, storage will improve the cement. Magnesia is injurious. This test may be accelerated by immersing the pats in a steam bath.

5. Strength: Briquettes having a cross-section of 1 sq. in. are made of neat cement and also of various mixtures of cement and sand. They are allowed to set one day in air and then are immersed in water. After periods of 24 hours, 7 days, 28 days, etc., they are broken by testing-machines and the breaking weights noted.

A good Portland cement should develop a strength of 175 lb. per sq. in. at the end of 24 hours; at the end of 7 days, 450 lb. per sq. in.; at the end of 28 days, 550 lb. per sq. in.

37. Does a quick-setting or a slow-setting cement give the greatest ultimate strength?

The slow-setting cement usually gives the greatest ultimate strength.

38. What effect has fine grinding on cement?

Fine grinding causes an increase in weight of the cement, as well as in its ultimate strength, and enables the proportion of sand used in the mortar to be increased.

39. Should cement mortar be used after lying over-night?

It should not be used.

40. What is grout? If cement gets hot during mixing, what is the cause?

Grout is a mortar of sand and cement, with sufficient water to make the mixture run freely. It is usually poured into crevices or joints in masonry to make solid work at places inaccessible to masons. If cement becomes hot in mixing, it contains free lime, which is in the process of slaking and is injurious to the work.

41. What defects should an inspector look for in opening a barrel of cement?

He should observe especially that the cement has not become damp and partly set.

42. Describe a quick, rough test for cement that can be made on the work without a machine.

Make a small pat of neat cement and note the interval of time until it resists slight pressure of thumb nail. Also note, after the cement is set, if the edges of the pat show cracks.

A ball 1 in. in diameter of neat cement is often made (by mixing with a little water) and allowed to set. It should not crack or crumble, but grow steadily harder.

43. What is mortar composed of, and how is it mixed?

Mortar is composed of lime or cement mixed with sand and a sufficient quantity of water to make the mass plastic. The proportions of the ingredients depend upon their character and the purposes for which the mortar is to be used.

The sand and cement are spread dry in alternate layers in a mixing box or on a platform and turned repeatedly with shovels until the mixture appears entirely uniform; it is then spread out basin-like, having a depression in the center into which the water

is poured. By means of a hoe the dry mixture is then drawn into the water and worked until the ingredients are thoroughly incorporated and the mass is uniform in character and of proper consistency.

44. What kind of sand should be used in mortar, and how do you test its quality?

Sand for mortar should be fine-grained, clean, sharp and free from loam, clay and other impurities.

Sand is tested for—

1. Fineness—Determined by passing through sieves of known meshes and noting the percentages retained.

2. Cleanness—Tested by rubbing a sample between the fingers and noting if dust adheres to them.

3. Sharpness—Tested by examination with the aid of a lens.

4. Freedom from impurities.

Presence of salts is determined by adding nitric acid and nitrate of silver to a sample of the sand previously allowed to settle in distilled water. A white precipitate indicates the salt.

Clay is determined by permitting a sample to settle in water. The clay, if present, will separate in a distinct layer.

45. What shall be used for mortar in walls?

All walls below the curb level shall be laid in cement mortar. Those above, in the same, or in cement and lime mortar mixed.

46. Name the common kinds of stone used in building.

The more common building stones are granites, gneisses, traps, sandstones, slates, limestones and marbles.

47. Describe briefly rubble masonry, ashlar masonry, and state the classes of structures for which these, and also brick masonry and concrete, are each adapted.

Rubble masonry is composed of rough, undressed stone; it may be coursed, uncoursed or cobweb; used for cheap retaining walls, foundations of buildings, piers and abutments of highway bridges, and the backing of walls, dams, etc.

Ashlar masonry is composed of cut stone, either coursed or random, laid in close joints. It is used for first-class retaining walls, piers of railroad and highway bridges, and facework of dams, abutments, anchorages, arches, etc.

Brick masonry is used largely for walls and piers of buildings, for column footings, for sewers, arches of small span, etc.

Concrete masonry is adapted for all classes of structures; especially adapted for under-water structures, such as pier foundations, etc.

48. Define the terms "quarry-faced," "rough-pointed," "fine-axed," "bush-hammered" as applied to the dressing of stone.

Quarry-faced refers to a class of masonry in which the surfaces of the stones are not dressed, but left as they come from the quarry.

Rough-pointed refers to surfaces of stones which have been dressed so that projections do not exceed ½ to 1 in.

Fine-axed refers to surfaces of stones which have been rough-pointed and then finished with a "fine axe" having a specified number of blades to the inch.

Bush-hammered refers to surfaces which have been rough-pointed, fine-pointed and then finished with a bush hammer.

49. What are "headers" and "stretchers," "quoins," "dowels," as referred to masonry?

"Headers" are stones or bricks used for tying the face of a wall to the backing. They are set so that the greatest dimensions lie perpendicular to the face of the wall.

"Stretchers" refer to stones or brick which have their greatest dimensions parallel to the face of the wall.

"Quoins" are stones at the corners of buildings or walls.

"Dowels" are straight pieces of iron entering holes on the upper face of one stone and the lower face of the stone above it, tying them together.

50. What is meant by breaking joints?

In laying masonry the joints are so arranged that they strike near the middle of stones in the course above and below. This is called breaking joints.

51. What is meant by row-locking?

If an arch is built in concentric rings with no bond but the mortar between these rings, the work is called "row-locking."

52. What is meant by racking?

In rack work the unfinished end is left in the form of steps, so that the new work can be thoroughly bonded with the old.

53. What is meant by toothing masonry?

When the unfinished end of a wall is so left that to continue the work bricks must be inserted between other bricks it is called toothing. It is bad practice because the mortar cannot be thoroughly worked in.

54. Outline specifications for first-class ashlar granite masonry.

The cement should be the best quality Portland, and should meet all usual requirements when tested.

The sand must be clean, sharp, free from loam.

The stone must be first-class granite, uniform in color, free from seams and other defects.

All stones must be cut to exact dimensions, the length not exceeding four times and the width not exceeding twice the depth.

All angles and arrises must be true, well defined and sharp.

Joints should be not more than $\frac{3}{8}$ in., dressed to full depth of stone and properly broken in adjacent courses.

Courses should be well bonded, there being at least one header to every three stretchers.

Face joints should be raked out for two inches before mortar has hardened and thoroughly pointed with 1:1 Portland cement mortar.

Plug holes should be at least 3 in. from arrises.

The surfaces shall be rock-faced with $1\frac{1}{2}$-in. chisel draft at the arrises cut on true lines.

The rock face should be bold 3 to 6 in. beyond the arrises.

The stones should be laid on their natural bed and all joints perfectly full of mortar. Spalls may be used only to bring the stones level, but as few as possible are to go in the work.

When work is done in cold weather special apparatus to heat the sand and stone must be provided.

In hot weather the masonry should be protected and kept wet.

In joining old work to new, special pains must be taken to secure a good bond.

55. State the important details of construction of a heavy masonry dam.

The important details are:

1. Temporary structures to divert the flow of the river should first be built so that the work of constructing the dam may be carried on in the dry. These structures should be of rigid and fairly permanent character and of sufficient capacity so that the work on the dam proper will not be endangered.

2. The excavation is then proceeded with, the material being disposed of to the best advantage. In making the excavation the slopes

should be protected from slides and the bottom kept well drained. The foundation should be carried down to solid rock, the soft and decomposed rock being removed.

3. All fissures, holes or seams in the bottom must be thoroughly closed by grouting, and springs should be led away below the dam or securely plugged.

4. Before starting the masonry the rock surface should be flushed and painted with neat cement mortar, and a rich concrete or mortar used to fill up the irregularities.

5. Every precaution should be used in laying the masonry to secure tight work.

6. Where the dam abuts into the hillsides special care should be taken to make the joints tight.

7. Where pipes or other structures are built through the dam, cut-off walls should be constructed and the work done in the tightest manner possible to prevent leakage.

56. In laying up the masonry in a dam, what measures as to shape of stone, cutting same, bonding same, and laying same will tend to make the tightest work?

1. As to shape, the body of the dam should be composed of large blocks of rubble, as few spalls as possible being used; the faces of the dam above the river bed should be constructed of large blocks of cut stone, laid in 1:2 mortar.

2. As to cutting, the rubble blocks should be trimmed roughly to remove irregular projections and feather edges. The face stones should be dressed to a true, even surface at the joints to a depth of a foot or more, the back being roughly squared. Special stones, such as required at inlets and chambers, etc., should be cut to exact dimensions.

3. As to bonding, the rubble composing the body of the wall should be thoroughly interlocked and unfinished work should be "racked back;" face stones should be bonded into the rubble backing by the use of frequent headers.

4. The stones should be laid on natural bed in first-class Portland cement mortar, all joints being entirely filled with mortar. The face joints should be inclined inward, so as to make bed joints if possible normal to face of dam. All face joints should be raked to a depth of about 2 in. and thoroughly pointed with a rich Portland cement mortar.

57. Describe minutely everything to be done in setting a large rubble block in the heart of such a dam, from the time the stone is lifted until the setting is complete. What objections, if any, are there to the use of grout in such a case? State fully and clearly.

a. After the stone is lifted give it a thorough drenching; meanwhile the mason should prepare the mortar bed for same; the stone is then raised and set on its natural bed in the place thus prepared. It is now raised again, the mortar bed inspected and sufficient mortar added to fill the joints. It is then finally set. Spalls should be placed only where necessary to give an even bed for the large block, as few as possible being used. No joints should be filled with mortar after the blocks are in place.

b. Grout is porous, has not sufficient binding qualities, and will not prevent the passage of water.

58. In the construction of a dam in stone masonry to resist the passage of water through it, state minutely every precaution to be taken to make the dam itself watertight?

1. The sand, cement and stone should all be of the best quality, and the mixing and using of the mortar carefully supervised.
2. The upper and lower faces of the dam should be built of ashlar laid in close joints.
3. The dam should be built on a well-prepared rock foundation, the rock being painted with neat cement before the masonry is laid.
4. The inside or backing may be of rubble or concrete.
5. The joints in the rubble must be thoroughly filled with mortar, large stones should be used, and as few spalls as possible; care must be taken that no open spaces are left under the stone.
6. The bonding should be thorough, horizontally and vertically, and all unfinished portions should be racked, so that on joining new work a good bond will be secured.
7. The face joints must be thoroughly pointed with 1:2 mortar.
8. In joining old and new work the old surface must be well cleaned and painted with cement grout before laying masonry.
9. No work should be done in freezing weather. The stones must be well wet before using. No mortar partly set must be used. In cold weather the sand and stones should be heated. In warm weather the masonry should be kept wet, as the loss of too much water interferes with setting and injures the masonry.
10. Where the dam abuts into the sides of the valley, proper embankments must be built to prevent the passage of water around them.
11. Should the foundation be seamy or springs be encountered, they must be securely plugged by grouting or otherwise.
12. Pipes or conduits passing through the dam should be protected by special cut-off walls and neat cement to avoid forming lines of seepage.

59. Describe what you would consider a perfect material for use in puddling. State also what you would do in case you would have a job of puddling to do and such material was not available?

The best puddle is made of coarse gravel 1 part, fine gravel 3.5, clay 2.0 and sand 0.15. The clay should be opaque and uncrystallized and form a plastic mass with water.

If this material is not obtainable gravelly loam may be used, the finest material being placed near the outside of the wall; or a mixture of equal parts of coarse gravel, sand and clay may be used.

60. Describe the best method of using puddle in order to obtain an impervious bank.

The gravel should be spread loosely in thin layers, and the clay spread upon it, the lumps being broken; the sand is then deposited on the clay. The material is thoroughly mixed by passing a harrow over it; it is well moistened and then rolled with a heavy, grooved roller to a compact mass. The finished puddle should not be exposed to the drying action of the air, but covered with a layer of dry clay and sand.

61. How many headers are required in stone walls?

Walls less than 24 in. in thickness should have at least one header for every 3 ft. in height and 4 ft. in length, extending through the wall. If the wall is over 24 in. in thickness, there should be one header for every six superficial feet of wall on each side and extending at least 2 ft. into the wall. Headers should be at least 18 in. wide and 8 in. thick.

62. In setting a heavy capstone on a brick bearing pier, what steps would you take to make sure that it was solidly bedded?

The stone should be well brushed and broomed, and wetted so as to insure its sticking to the mortar, and the pier wetted on top; sufficient mortar should then be spread, adding a little water if necessary, to make the stone come to an even bearing, distributing the weight over the entire area of the pier. The stone must be perfectly level to insure good work.

63. Referring to the above, would it be a good idea to use wedges in making the stone level?

Not at all; they cause unequal bearing, throwing the weights on small areas, which often causes the stone to crack.

64. In a wall 10 ft. thick, how long should the stretchers be?

The stretchers in a 10-ft. wall should be 4 ft. in length.

65. How thick must ashlar facing be?

All ashlar facing must be at least 4 in. thick and properly bonded in with the backing.

66. Must a dry wall be laid differently from one built in cement?

In building a dry wall, the bed must be kept even and the wall be made one-half again as thick as would be necessary for one laid in mortar. Special attention must be paid to secure good bonding.

67. What is concrete, of what composed, in what proportions and how should its ingredients be mixed?

Concrete is artificial stone made by mixing sand, cement and broken stone or gravel with sufficient water to make the mass workable.

The proportions of the ingredients to be used depend upon the character of the work and the nature of the ingredients themselves.

The usual proportions are—

1 cement, 2 sand, 3 stone.
1 cement, 2 sand, 5 stone.
1 cement, 3 sand, 5 stone.
1 cement, 3 sand, 6 stone.

In mixing concrete by hand the cement and sand, previously measured in boxes provided for the purpose, are spread out on the platform and thrown until the mass appears uniform. Water is then added, the mixing continued, the mortar spread out, and upon it is spread the measured quantity of stone. The entire mass is then thrown with shovels until the sand, cement and stone are thoroughly mixed, enough water being used to make the concrete plastic.

68. State briefly the important points regarding mixing (by machine) and placing heavy concrete masonry.

In mixing concrete by machinery the important points to be observed are—

1. That the specified proportions of the ingredients are fed into the mixer at all times.

2. That the quantity of water is uniform and of proper amount to produce the desired consistency.

3. That the ingredients are thoroughly mixed.

4. That when the mixer is emptied, its entire contents are removed.

5. When the mixer is stopped it should be flushed with water and no concrete partially set or otherwise should be permitted to remain in it.

6. The mixer should be located as near the work as possible.

7. The concrete should have a low fall after leaving the mixer, so that the materials do not separate.

8. If transported the concrete must be carried in water-tight cars or barrows.

9. As soon as placed the concrete should be well compacted, all corners being thoroughly filled.

10. The forms must be firm, unyielding, have the closest possible joints and smoothed on the inside.

11. A richer concrete should be deposited near all exposed surfaces.

12. The work should be supervised by a competent inspector.

69. When it is necessary to lay concrete under water, how can it be done with good results?

Concrete may be deposited under water—

1. In paper or burlap bags carefully lowered and placed into position with the aid of divers.

2. A V-shaped box of wood or iron is commonly used. It is filled with concrete and lowered by a crane. One of the sloping sides is swung open by pulling out a pin, which is attached to a string reaching the surface, and the concrete deposited in place.

3. A long hopper-shaped tube called a "trémie" is also used. It is open at both ends and its length is adjustable. It is suspended in place by a crane, and a continuous flow of concrete maintained through it. The tube is thus kept full and separation of material is avoided.

In all methods no opportunity should be given for the material to separate. Leveling should be done by rakes, no ramming being allowed.

70. (*a*) How would you unite a new layer of concrete with old? (*b*) What is gained by storing Portland cement before using it?

(*a*) By thoroughly washing and scrubbing the surface of the old concrete and painting the surface with neat cement or a rich mortar before the new concrete is laid. It is claimed by some that the use of tempered concrete at the junction of old and new work will give good results.

(*b*) Fresh cement contains free lime, which causes expansion or "blowing" and might endanger the structure in which it is used in this condition. During the time of storing the free lime is changed to carbonate of lime, and in this state the cement does not swell.

71. (*a*) What are the objections to tempering concrete? (*b*) Why are masses of concrete left wet for several days? (*c*) Why do you

mix broken stone and gravel wet? (*d*) Why do you not use the shovel in laying concrete? (*e*) When is concrete cheaper than brick?

(*a*) Tempering concrete weakens it greatly. Tempering disturbs the setting, which has already begun, reducing the strength.

(*b*) Evaporation, percolation, and absorption by the stones cause a large loss of water in the mass of concrete and thus deprives it of the necessary water required for proper setting. In order to avoid this, the mass of concrete is kept wet.

(*c*) Broken stone and gravel are mixed wet, as they absorb water from the mortar and would therefore retard and interfere with its setting.

(*d*) If a shovel is used in laying concrete the mortar sticks to the shovel and will thus be separated from the stone; the water will run off the shovel, carrying the lightest material with it. This will be the case especially where the fall is considerable.

(*e*) Concrete is cheaper than brick when used in large masses, and where expensive and elaborate forms are not required.

72. (*a*) Upon what does the imperviousness of concrete to the passage of water depend? (*b*) Describe clearly and fully the method you would take to determine the best proportions of the several ingredients in order to make water-tight concrete.

(*a*) The imperviousness of concrete depends upon—

1. Character and proportions of the cement, sand and stone, and the amount of water used.
2. Upon the thoroughness of the mixing.
3. Upon the care in laying.

(*b*) Provide a measure of known capacity, fill it with the sand to be used and then add water to the point of overflowing; note the quantity, and thus determine the percentage of voids in the sand. In the same way determine the percentage of voids in the stone. Now, by starting with a barrel of cement as a unit, the quantity of sand which can be used for the mortar is determined from the known percentage of voids; thus, if the sand has 40% voids, 2½ barrels of sand may be used, giving 2½ barrels of mortar. The amount of stone can then be determined in the same way; thus if the voids in the stone are 50% there will be required 5 barrels of stone for each 2½ barrels of mortar, the whole making 5 barrels of concrete. The proportion will then be 1 volume of cement, 2½ volumes of sand and 5 volumes of stone, and for other percentages of voids it will vary accordingly. Practically a little more cement than necessary to fill the voids should be added in mixing the mortar. Enough water should be used to make the mass plastic.

73. What is rubble concrete and when is it used?

Rubble concrete is a mass of concrete in which are embedded blocks of rubble. It is used in the body of large retaining walls, dams and foundations to save concrete and therefore decrease the cost of the structure. Care should be taken that each block should be thoroughly embedded in the concrete and that the blocks are not placed too near the exposed surfaces.

74. Describe the best method of setting concrete blocks for a bulkhead under water, including location as to line and level.

The necessary preparation and leveling of the site is done by divers with the aid of heavy iron straight-edges. The blocks are brought to the site and lifted by a crane. When swinging into position they are suspended about half their depth in the water to reduce the load on the lifting tackle. When near the right location they are lowered, and when about 3 or 4 inches above the lower course they are carefully adjusted. Accurate adjustment for line may be secured by timber guide-pieces wedged into the dowel grooves in the blocks, and by stop-timbers attached to the blocks already set. Divers assist in the work when necessary. After the blocks are set the dowel grooves are packed full of concrete.

75. Describe a good quality of bricks and state how you would know a good brick from a poor one?

Good bricks are usually of dark, reddish-brown color, emit a clear, ringing sound when struck, absorb a small percentage of water, do not crumble easily and do not scale or swell in water.

Poor bricks are reddish-yellow in appearance, emit a dull sound when struck, absorb 15 to 25% of water, crumble easily and may scale or swell when left in water.

76. In how many ways is brickwork bonded to make good work in heavy walls?

The usual bonds are:

1. Cross Bond—A course composed of headers and stretchers intervening. The joints in the second stretcher course come in the middle of the first.
2. English Bond—Alternate courses of headers and stretchers.
3. Flemish Bond—Headers and stretchers alternating in the same course.
4. Ordinary Bond—One header course following three or five successive stretcher courses.

77. What should be the proportion of "headers" to "stretchers"?

The proportion depends upon the character of the work. In brickwork every sixth course should be a header.

In stone walls there should be one header to 3 stretchers or 1 header for each 12 sq. ft. of wall surface.

78. How should 8-in., 12-in. and 16-in. walls be bonded?

In an 8-in. wall, the headers reach through. In a 12-in. wall, they reach from each face through two-thirds of the wall. In a 16-in. wall the two middle courses must be bonded separately. At least one-sixth of the face of the wall should be headers.

79. What should be done to brick before using?

They should be well wetted.

80. Why should bricks be wet before laying them?

Bricks when dry absorb the water from the mortar which is necessary for proper setting.

81. Give precautions in laying bricks where great strength is required.

The bricks should be thoroughly wetted just before laying. Every brick must be completely imbedded in mortar under its bottom, on its sides and on its ends at one operation. Every joint must be full of mortar. The joints must be close, not exceeding $\frac{1}{4}$ in., and well pointed. Unfinished work must be racked. Before new work is added, the old work must be cleaned thoroughly and well moistened. The work should be well bonded.

82. May hollow bricks be used in walls?

The inside 4 in. of all 12-in. walls may be built of hard-burned, hollow clay or terra cotta brick of the same dimensions as the rest of the brick. Thicker walls may have a larger percentage of these bricks.

83. How thick should the brick backing be to ashlar facing?

The backing should be of the same thickness as would be required for a wall without the facing.

84. What do you understand by the word skewback when used in masonry?

A skewback is a brick or stone cut on a bevel to receive the arch ring.

85. What is a foundation wall?

A foundation wall is a wall below the curb level.

86. Of what material and how are foundation walls to be constructed?

They should be built of stone or brick. They should, if built of stone, be at least 8 in. thicker than the wall next above them for a depth of 12 ft. below the curb level; and for each additional 10 ft. in depth they should increase 4 in. in thickness. If built of brick, they should be 4 in. thicker than the wall above and increase 4 in. for each additional 10 ft. over 12 ft. in depth.

87. Of what material must the walls of all buildings other than frame buildings be constructed?

They must be constructed of stone, brick, iron or other hard, non-combustible material.

88. What are bearing walls?

The walls which take the floor loading are called the bearing walls.

89. What should be the thickness of non-bearing walls?

They should have a minimum thickness of 12 in., and, other things being equal, they may be 4 in. less in thickness than bearing walls.

90. What change must be made in a bearing wall that has openings?

If the openings amount to 25% the wall must be increased 4 in. in thickness and an additional 4 in. for each additional 10% beyond the 25 per cent.

91. Who must preserve the party wall?

If the adjoining party wall is to be used by the persons making the excavation, they must preserve it.

92. How does the height of the building affect the thickness of the walls?

The thickness of the walls must be increased as the height of the building is increased.

All buildings having a depth of 105 ft. without any cross walls or supports must be 4 in. thicker than otherwise specified.

93. What should be the thickness of partition walls?

Partition walls should be 8 in. thick when they carry beams of less than 26 ft. span. They must be thicker if carried over 50 ft. in height.

94. What must be done with party walls and exterior walls on which there will be no cornice, gutters or crown mouldings?

Where the walls are 15 ft. high or more they must be carried up 2 ft. above the roof and shall be coped with stone, well-burnt terra cotta or cast iron.

95. What is a retaining wall and where used?

It is a wall built to support an earth embankment. Retaining walls are used to form areas, to uphold street, railroad and other embankments, and to protect excavations and adjoining structures.

96. How and of what should the base course of foundation walls be laid?

It should be of stone or concrete, or both, or of concrete and stepped-up brick work. If of concrete, it must be 12 in. thick; if of stone, the stone must be at least 2 ft. by 3 ft., at least 8 in. thick, and at least 12 in. wider than the bottom width of the wall above. All base stones must be laid crosswise, edge to edge, and well bedded. When stepped-up brick work is used the lower course must cover the concrete, being at least 1 ft. wider than the wall above, and each step per course should not exceed 1½ in.

97. What shall be the general dimensions for walls in private dwellings?

The basement walls of dwelling houses less than 35 ft. high and 20 ft. wide if of brick shall not be less than 12 in. thick, and the other walls shall be 8 in. thick. But no party wall shall in any case be less than 12 in. thick.

98. In iron cage construction, how is the masonry of the walls supported?

The walls are supported upon steel girders or beams, which are built between the steel columns at each floor level; the columns carry the weight of the walls down to the foundations.

99. What precautions should be taken in building a retaining wall?

The excavation should be carried down to a good foundation bed, the minimum being about 2 ft.

The bottom should be freed from all perishable matter, which should be replaced by firm soil or sand; and it should be watered and rolled.

The heaviest courses should be laid at the bottom.

The masonry should be well laid and securely bonded, frequent headers being used and spalls avoided as much as possible.

Drainage should be provided for by means of weep holes or drains laid along the heel of the wall. A layer of gravel may be placed adjacent to the wall to drain the backing.

The backing should be deposited as compactly as possible.

The bed joints of the masonry in the interior of the wall should if feasible be somewhat inclined.

100. How would you examine scaffolds and derricks?

The inspector should examine the construction of the scaffolds, see that sufficiently strong timbers are used and that the same are properly anchored from story to story. Special attention should be paid to the flooring. Derricks should be well supported and anchored with at least 4 or 5 guys. Special precautions should be taken with regard to the condition of the different members, the ropes, fastenings and connections.

101. How should a derrick be placed and anchored?

It should be so placed that there will be no danger of it sliding on its base or of the base tilting. The top should be supported by four or five guy ropes, securely anchored and of sufficient strength.

102. How would you store materials as to public safety and convenience?

Materials must not be piled within 4 ft. of any fire hydrant or fire-alarm box. The Fire Department must be given access at all times and in all places to all buildings for extinguishing fires.

All material, when stored temporarily in street, should be watered if so ordered. Paving stones, flagging, etc., if to be reused, shall be moved at once to another block or neatly piled along route, so as not to obstruct use of walks and street by pedestrians and vehicles.

103. Under what conditions as to nearness of excavation, depth, character of soil, etc., would you consider it necessary to underpin buildings adjoining excavations?

Generally speaking, buildings whose foundation walls are above the bottom of excavation and within 10 ft. of same require underpinning in case they cannot safely be supported by sheeting.

104. Give essential features of the process of underpinning a large building and every precaution to be taken.

The essential features are:

1. The preparation of a firm foundation bed at or below bottom of excavation, to take the loads on the piers or columns.

2. The erection of footing courses and columns on these foundation beds to support the building.

3. Setting beams on these supports and wedging them under the structure.

The precautions to be observed are:

1. In excavating for foundations, etc., shafts and trenches should be dug as small as possible and far enough from building foundation not to endanger it.

2. The operation of wedging should be done with great care, so as to prevent undue strains or unequal settlement.

105. What precautions with regard to fire-proofing are taken in tenements, hotels and flats?

In 5-story buildings iron beams with fire-proof arches between them are used for the first floor. The stairway from the basement to the first floor is enclosed in stone walls with an iron door swung at the opening to the basement. No closet is allowed under said stairway. For 6-story houses and over, the halls and stairways should be enclosed in brickwork.

106. How are doors for theatres constructed?

They must be 5 ft. or more wide, according to the seating capacity. They must open outward, be fastened with catch bolts and constructed of iron unless otherwise permitted by superintendent of buildings.

107. Must the stairways in tenements and flats all lead to the roof?

At least 1 stairway in each house must lead to the roof and be enclosed in a bulkhead built of fire-proof material.

108. How are hearths for fireplaces to be supported?

They should be built upon trimmer arches. These arches must be 16 in. wide from the face of the chimney breast. The arch shall be built of brick, stone or burnt clay.

109. What should be the size of a drain pipe for a 5-story house with two families on each floor?

House drains and house sewer must be at least 4 in. where water-closets empty into them. If rain water discharges into them they must be at least 6 in. and upwards, depending upon the area drained.

110. How shall the ends of beams be supported and secured?

All beams should have their ends resting 4 in. in the walls or on other beams or brackets, except header and trimmer beams. In no case shall beams rest on stud partitions. Each tier of beams should be securely anchored to the side, front, rear or party walls at intervals not exceeding 6 ft., with strong, wrought iron anchors and not less than $1\frac{1}{2}$ by $\frac{3}{8}$-in. stops.

111. What are the requirements as to the bearings of iron beams and lintels?

Beams should rest on iron templates, or stone of sufficient strength and width to properly distribute the weight imposed. The stones should not be less than 5 in. Lintels should rest 4 in. on piers or walls.

112. Why is it desirable to anchor the ends of roof trusses to the walls supporting them?

To tie the walls securely together and thus prevent them from spreading.

113. If you found the ends of a wooden column untrue, what should be done?

They should be cut true and iron plates set under to bring them up to the proper height.

114. What span is allowable in stores and warehouses?

No span between partition walls or columns shall be more than 25 ft.

115. How should the bearings of iron beams be arranged on brick walls?

They should be placed on stone slabs about 1 ft. square.

116. When vaults are built under sidewalks, what extra masonry must be provided?

A retaining wall must be built to hold up the street and the party walls must be carried forward under the sidewalk to the retaining wall. The vault roofs should be built of non-combustible material and any holes for the admission of coal should be covered with rough iron covers, set flush with the pavement.

117. Where is a trimmer beam used?

At the head of stairs.

118. Is it proper to set a column on the joint between the end of two wooden girders? If not, why not?

No. The load may not be carried down vertically. There is generally a weak spot at the joint. In case of settlement the beams are likely to draw apart, and throw the column out of plumb.

119. In using drift bolts for fastening timber, what precautions are necessary to obtain the greatest possible holding power in the timber?

The bolts should have a larger cross-section area by about 25% than the holes into which they are driven, their ends slightly pointed with a hammer, and they should be of sufficient length to make a firm connection. Round bolts are preferable to square, as they do not tear the wood.

120. Is it allowable to carry roofing over a party wall?

The party walls must extend above the roof and be properly coped in all cases.

121. What size lintels shall be used for door and window openings.

For openings up to 4 ft. in width the lintel must be 8 in. high; up to 6 ft. in width, 10 in. high; up to 8 ft. in width, 12 in. high, and the full thickness of the wall. No lintel shall be less than 4 in. thick or have a bearing surface of less than 4 in. at each end.

122. May wooden beams of adjoining properties which rest on the same wall be placed with their ends abutting?

No; they must have at least 4 in. of solid brickwork between them.

123. What is the least thickness a wooden beam may have?

Three inches.

124. What is a tie anchor?

It is a rod used to hold two or more other parts firmly together and is always in tension.

125. What method would you use to bring the beams of a tier to a level?

The beams should be cut off on the underside if too high and blocked up with slate.

This should not be done when the difference in the depth or height is too much, in which case the walls should be relaid to meet requirements.

126. Why are tie rods used where arches are built between beams?

To keep the beams from spreading.

127. State the conditions under which a cellar may be used as a dwelling?

The cellar must be 8 ft. high throughout; the ceiling must be 2 ft. above the curb level; the space beneath the floor must be cemented; the area must extend along the full front and must be 2 ft. 6 in. wide, being 6 in. below the floor level of the part occupied, and properly graded and drained. The steps must have open risers.

128. What is to be observed in building flues?

That they are lined with cast iron, clay or terra cotta pipes and that they are enclosed with at least 4 in. of brickwork on all sides.

129. How near to a hot air flue may a wooden beam be placed?

No wooden beams shall be placed nearer than 8 in. to a flue, and in this case the beams should be protected with metal.

130. What are the recesses allowable for pipes?

The recesses for pipes should not exceed one-third of the thickness of the wall and they must be sealed with masonry at the top and bottom of each story for one foot in height.

131. How must hot air registers be placed in floors?

They must be set in stone laid in plaster of paris or gauged mortar. There must be at least 2 in. clear space between the flue and the floor.

132. What buildings must be fire-proof?

All buildings over 75 ft. in height.

133. What air space must each room have?

At least 600 cu. ft. Each room must have a window opening into the outer air, at least 12 sq. ft. in size, measured between stop boards. In addition there must be a transom over the door except where the latter opens into a public hall.

INSPECTOR OF STEEL.

134. What are the several qualities of cast and wrought iron and wrought steel which make them useful for various classes of construction? Describe briefly the work for which each is well adapted and in general the methods by which you would test them.

Cast iron is durable, possesses great strength in compression, and can be readily cast in any desirable shape, making it a convenient material to use for water pipes, columns, column footings, bed plates for machinery, etc.

It, however, is brittle and should not be used where subject to heavy vibration, impact or tensile stresses.

In inspecting castings, look for honeycomb. Blow holes or sand holes when filled with sand or loam are detected by a dullness in sound on tapping. Examine also for shrinkage cracks, large ridges at partings and flaws on edges; warped castings and those of incorrect dimensions should be rejected.

For testing the strength, bars 14 or 26 in. long, 3 in. wide and 1 in. thick are prepared and the breaking load transversely and in tension obtained, the resulting deflection and elongation being also noted.

Two principal varieties of cast iron are made: White, which is hard, brittle and difficult to work; gray, which is soft, tough and easily worked.

They differ in the amount of carbon in chemical combination.

Wrought iron is adapted to structures which are subject to alternating compressive and tensile stresses, but in which the unit stresses are not excessive, such as rivets, beams, girders, truss members, columns, etc. The metal is durable, malleable, elastic and readily worked.

In inspecting wrought iron look for "cold short" (containing phosphorus), indicated by bright crystalline fracture and discolored spots; also for red short (containing sulphur, arsenic, etc.), indicated by cracks on edges of bars.

Tough iron has a fine, fibrous and close texture.

Wrought iron is tested by bending prepared bars hot and cold. No fracture should result.

The tensile strength is determined from test pieces usually about 18 in. long by 1 in. wide, and of the original thickness.

135. (*a*) Describe the difference in appearance of fractures of good steel and of good cast iron. (*b*) Also how both differ from that of good wrought iron?

(*a*) When broken slowly the fracture of steel presents a silky, fibrous appearance with an angular and irregular outline. When

ruptured suddenly the fracture has a granular appearance with the surface usually even and at right angles to the length. The fracture is often cup-shaped. The color is light pearl-gray.

The fracture of cast iron should be of a light bluish-gray color and of close-grained texture with considerable metallic luster.

(*b*) Good wrought iron is indicated by small crystals of a uniform size and color, and fine, close, silky fibers.

136. Describe the appearance of each of the above when the material is poor.

Fracture of poor steel is dull and sandy looking without luster or sheen; yellowish color; burned steel has a whitish hue and granular fracture.

Fracture of poor cast iron shows mottled surface, either with patches of darker or lighter iron, or it may have crystalline patches; very bad specimens also show air holes.

Fracture of poor wrought iron shows coarse crystals, blotches of color, loose, open and blackish fibers. Flaws in the fractured surface indicate defects in the processes of manufacture.

137. State what a drift pin is for, and whether it has any effect upon the strength of the material in which it is used, and what that effect is.

A drift pin is a round piece of steel, made slightly tapering, used for bringing pieces together preparatory to riveting.

The use of a drift pin to enlarge a hole causes a hardening of the material around same, and a consequent loss of ductility and an increase in the elastic limit of the latter. This is considered very injurious. Specifications prohibit the use of drift pins except for bringing pieces together.

138. (*a*) Describe the proper way of testing the thickness of a C. I. column.

(*b*) Describe carefully the method of testing the soundness of a C. I. column.

(*c*) What parts of a C. I. column require special care in examination to prevent accident?

(*a*) The thickness of a C. I. column is usually tested by drilling a $\frac{3}{8}$-in. hole at one or more points and measuring same. A round column may be laid on a pair of rails set horizontally. The column is pushed slightly and note is made whether it rolls uniformly or always settles on one side. In the latter case the metal is thicker on that side, and a test-hole should be drilled on the opposite side.

(*b*) The soundness of a C. I. column is tested by tapping the

column all around with a hammer and noting the sound. Blow holes or sand holes filled in with sand from the mould give a dull sound upon tapping. Cracks are also indicated by a dull sound. The middle of the column must be examined carefully for cold short.

(*c*) The connections of lugs, brackets, capitals and bases require close examination to discover flaws, shrinkage and blow-holes.

139. (*a*) Suppose a cast iron column to be ½ in. too short, what would you do?

(*b*) Suppose such a column to have one of the ends not turned square, what would you do?

(*a*) If the column is ½ in. too short, put a ½-in. steel plate under it to bring it to the proper elevation.

(*b*) If one of the ends is not turned square the column should be sent to the nearest shop and corrected, provided that too much metal is not removed. Sometimes it may be allowable to leave the column as it is and put a wedge-shaped shim plate between the incorrect end and the next column. In a very bad case the column must be rejected.

140. Where, in a detail drawing, a number of small circles are shown in some parts, all filled in with hatching, or entirely black, what does it indicate?

Such circles represent holes for field rivets or field bolts.

141. Would you consider it necessary to make any inspection of girders, posts or other iron work after delivery on the ground before erection? If so, state exactly and fully what that inspection should be.

The iron work received on the ground must be examined to see if it tallies with the invoice sheets, and every piece must be closely scrutinized to see if the shop inspector's stamp has been placed thereon. The inspector of erection must also examine all material received to see that it has not been bent or otherwise injured during transportation from the shops. Anything overlooked by the shop inspector must be corrected by the inspector of erection.

142. Suppose that during erection certain rivet holes do not come "fair," how should such errors of every kind be corrected?

Holes which do not match exactly during erection must be enlarged slightly by reaming. If a hole in one or more connecting plates has been omitted, it must be drilled in the field.

If a hole is present where no rivet or bolt is required it should be plugged up with lead.

143. Is there any difference in the strength of riveting done in the shops and on the work? If so, which is the stronger and why?

Riveting done in the shops is considered stronger than that done in the field. This is especially true of hand-driven rivets. With the modern pneumatic riveters, there should be no difference in the strength of shop and field work, although most specifications require 25% more field than shop rivets in hand-driven work, and about 10% in the case of machine work. Shop rivets are considered stronger, as they are driven under more favorable conditions as to handling of materials, heating of rivets and inspection of work. Of course machine-driven rivets can be more uniformly made than hand-driven.

144. How would you inspect a job of riveting?

With a special hammer weighing about a pound, blows are struck sharply on each side of the head of the rivet.

Loose rivets will be indicated by jar or rattle.

Also examine edges of rivet head, observing that there are no marks of caulking tool. See that the heads are concentric, fit closely all around and are free from cracks, and that no impress on the metal around the head has been made in driving the rivet.

The rivet heads should be full size.

145. In inspecting a heavy casting as a base of a column, what defects would you look for?

In inspecting castings look for honeycomb. Blow-holes or sand-holes when filled with sand or loam are detected by a dullness in sound, upon tapping. Examine also for shrinkage cracks, large ridges at partings and flaws on edges. Warped castings or those that are incorrect in dimensions should be rejected.

146. (*a*) Where bolts are to be used permanently in a piece of work, how is the strongest job obtained? (*b*) Which is the stronger, bolting or riveting, and why?

(*a*) By drilling the holes in connecting parts, using a steel templet if necessary. (*b*) Riveting if well done is stronger than bolting, because the rivet is forced into the hole and fills it completely, and the rivet heads upon cooling bind the members more firmly together. In riveted work, moisture cannot work into the joint and cause rust and deterioration.

147. Are any precautions against wind ever necessary in the erection of iron work in a building, and if so, what?

During erection the wind bracing and brackets must be connected up as quickly as possible, especially in a skeleton building in which the steelwork is carried up rapidly. Otherwise there may be a failure of portions of the ironwork during a high wind due to overstraining.

148. How should specimens for testing be chosen and prepared to fairly show the quality of (*a*) wrought iron; (*b*) cast iron?

(*a*) The test specimen for wrought iron can only be taken after the material is rolled and must be cut from the full-sized bar. The test piece for tensile strength, limit of elasticity, and ductility is usually cut about 18 in. long, the same thickness as the finished bar. (*b*) The test-bars for bending of cast iron are usually 3 in. wide by 1 in. thick and either 14 in. or 26 in. long. One is poured before and one after the casting is poured. The bars for tensile strength are about 18 in. long and usually turned down in a lathe in order to remove the exterior scale. They are marked similar to the specimens for wrought iron or steel.

149. What conditions or quality of material or manufacture are indicated by the following tensile test results: (*a*) Elastic limit 38 000 lb. per sq. in., and ult. strength 45 000 lb. per sq. in. (*b*) Ultimate strength 80 000 lb. per sq. in., elongation in 8 in., 10%. (*c*) Ultimate strength 80 000 lb., elongation in 8 in., 25%. (*d*) Ultimate strength 56 000 lb., elongation in 8 in., 35%.

(*a*) Shows low ultimate and high elastic limit usually found in material that has been punched or sheared. (*b*) The material is high carbon steel. (*c*) The material is rolled nickel steel (about 3% nickel), possessing great tensile strength and ductility. (*d*) The material is soft or rivet steel.

150. (*a*) What should be considered in surface examination of material? (*b*) State defects likely to be found in both steel and cast iron.

(*a*) The material should be examined for—

1. Color.
2. Defects due to casting or rolling.
3. Hardness.

(*b*) The surface defects of steel are: Blow-holes and pipes; pits; cinder spots; stars; cracks; laps or laminations; seams; snakes and cobbles.

The surface defects of cast iron are: Swells, scales and blisters, cold shorts, etc.

151. What is (*a*) piping; (*b*) "burning;" (*c*) how do you inspect to discover them?

(*a*) A "pipe" is a cavity produced by the outside of an ingot cooling more rapidly than the inside. This defect usually occurs within conical lines in the upper third of the ingot.

(*b*) "Burning" occurs when a piece of steel is overheated.

(*c*) "Piping" is discovered in an ingot by cutting off the metal near the upper part. If an ingot having pipes is rolled into shapes the defect will show in cavities in the rolled material.

"Burning" is indicated by small cup-like holes. A burnt rivet throws off sparks upon being withdrawn from the fire.

152. (*a*) What are the essential points to be inspected about riveting; (*b*) How are loose rivets made to seem tight under a hammer test; (*c*) how would you know deceit was practiced?

(*a*) 1. The rivet metal must be tested for tensile strength, bending and ductility.

2. The holes must match correctly.

3. Rivets must be heated correctly.

4. Rivets must be driven to fill holes completely, with full concentric heads. All rivets must be tight.

(*b*) Loose rivets are sometimes made to appear tight by going round the edges with caulking-tool. Rivets are also made to appear tight by placing the "snap" sideways upon the rivet and striking it a few heavy blows with a sledge.

(*c*) If a caulking-tool has been used, the marks left by the tool will be apparent upon close examination. If the "snap" has been hit sideways it will cut a ridge in the plate and force the metal against the head.

153. State all the details to be inspected in the case of a finished girder for a plate girder bridge span.

The Inspector should see that—

1. The correct shapes and plates are used.

2. That stiffeners bear tightly on top and bottom flange angles.

3. The girder must be straight and true and the web must not project above the flange angles.

4. The spacing and number of field holes must agree with those shown on plans.

5. The length and all other dimensions of the girder must be correct.

6. Web splices and all abutting surfaces must be made to close tightly.

154. State all the details to be inspected in the case of a finished post for a pin-connected span.

1. That correct shapes and plates are used and that all dimensions are correct.
2. All rivets must be tight, and abutting surfaces must be made to close tightly. All parts must be free from twists and bends.
3. The pin holes must be bored exactly perpendicular to the vertical plane passing through the center of the member, and the distance from center to center of pin holes must be correct.

155. How would you check the field connections of (*a*) a skewed portal; (*b*) a lattice girder of which members are shipped separately?

(*a*) Try the connections on a templet.
(*b*) Assemble the girder in the shop before shipping.

156. What are the important points to be inspected about painting to secure thorough preservation from rust?

1. All material must be thoroughly scraped and cleaned with a steel brush before applying the paint.
2. All surfaces which are to be in contact must have a coat of paint applied before riveting.
3. The composition of the paint must comply with the specifications.
4. The paint must be well worked into all joints and open spaces.
5. Pins, bored pin holes, friction rollers and screw threads must be coated with white lead and tallow before being shipped from the shop.

157. In first-class work what variations are allowable in the following: (*a*) Pin and pinhole connection; (*b*) riveted connection; (*c*) length of stringer; (*d*) length of floor beam; (*e*) length of eyebar; how should the last be measured?

(*a*) The allowable variation may be $\frac{1}{50}$ in. for pins less than $4\frac{1}{2}$ in. diameter, and $\frac{1}{32}$ in. for pins of a larger diameter.
(*b*) Holes must match almost exactly.
(*c*) Stringer may be $\frac{1}{16}$ in. short.
(*d*) Floor beam fitting in between posts may be $\frac{1}{16}$ short.
(*e*) Eye-bars may vary from the calculated lengths $\frac{1}{16}$ in. for each 25 ft. of their length.

The centers of the holes are first marked on the eye-bars and this distance is measured. After the holes are bored the distances between the tops of the holes and also between the bottoms are measured. The average of these lengths will give the distance between the centers of holes.

158. In the storing of structural steel on the ground prior to erection, what general rules should be observed?

The material must be carefully piled up on skids or timber so as not to touch the ground. All members should be so placed that they will shed rain-water. Material should be so placed as to require the least amount of handling when needed for erection and cause as little interference with traffic as possible.

159. Describe an erection sheet and state how you would use it.

An erection sheet is an outline diagram of a structure giving the relative positions of all members and indicating each member by its shop mark. When a member has been received on the ground it should be checked on the erection diagram.

160. (*a*) What is falsework? (*b*) What is it used for in bridge work? (*c*) Is falsework employed in the erection of all bridges? (*d*) Where falsework is being used and a considerable part of the bridge has been assembled on it, what particular feature of the falsework would you carefully inspect, and how often would you make the inspection?

(*a*) and (*b*) Falsework consists of timber or steel columns, trestles, etc., built under a bridge or other structure to support the same during erection and until it has been connected up and is able to support itself.

(*c*) Falsework is not necessary in the construction of cantilever bridges, or of plate girder and short truss bridges.

(*d*) Examine the wedging and see whether the falseworks have settled below the correct position of the truss. This should be examined every day.

161. What are the essential points to be inspected about the following processes: (*a*) Assembling; (*b*) punching?

(*a*) In assembling, the inspector must see that the correct sizes, shapes and thicknesses of metal are put together, that the holes match, and that the correct sizes of holes are used.

(*b*) In punching the inspector must examine the punch-dies to see that the edges of same are sharp and unbroken, and that the difference between the upper and lower die does not exceed $\frac{1}{16}$ in.; also, that the holes are punched exactly at the points marked.

162. Describe in detail the usual order of assembling the parts of a "through truss" riveted highway bridge.

Chords are first laid down on falseworks with wedging at the panel points to allow for raising or lowering during assembling;

the posts and diagonals of a panel are then put in place and lastly the top chord; the best way is to start at the center of the truss and work towards each end.

163. What must be particularly noted in assembling connections regarding the surfaces which become inaccessible after assembly?

Surfaces which are inacessible after assembling must be given two coats of paint before the parts are assembled.

164. State what you would do, if in assembling you find a member bent or otherwise injured?

Send the member to the straightening machines and have the defect remedied.

165. How should large steel pins be driven in connections and how should they be protected?

Large pins are driven into place by means of jacks. They are protected during driving by pilot heads and nuts.

166. What is the object of each of the following tests of wrought steel: (*a*) Cold bend; (*b*) hot bend; (*c*) quench and bend; (*d*) drift?

(*a*) To test cold-shortness or the presence of phosphorus.
(*b*) To test hot-shortness (containing sulphur, arsenic, etc.).
(*c*) To see whether it will stand hardening.
(*d*) Made to see how much a rivet hole can be enlarged under different conditions without fracturing the material.

167. In high buildings with iron or steel columns how should the abutting faces on flanges of superimposed columns be finished? Should the use of lead or shims of iron be allowed between such surfaces when the pressures are heavy?

All cast-iron, wrought-iron and steel columns should have their bearings faced smooth and at right angles to the axis of the column, and when one column rests upon another they should be securely fastened together without lead or iron shims between them.

168. What is the law regarding open columns?

They must have their ends covered with bed-plates.

169. How should iron cribbing be treated before being laid?

When used below high water, it should be entirely coated with coal tar or paraffine varnish before being placed. Iron footings for columns must be similarly treated if below water level.

170. To what points should you give attention in erecting iron-work in buildings?

See that the parts are of the required sizes and properly connected by a sufficient number of rivets; that all the rivets are properly headed and fast; that the different parts are not excessively strained due to certain members being short or long. That the parts of columns are well centred.

171. How may beams be strengthened at supports?

They may be strengthened by struts or else by cushion rafters.

172. What is a cantilever and why is this construction used in large buildings?

A cantilever is a wooden or iron block or beam projecting from a wall or column to bear mouldings, balconies and the like. The principle is applied in the construction of bridges to support enormous weights. It is also used to enable a symmetrical spreading of the foundations in large buildings.

173. What factor of safety shall be allowed in computing the sizes of beams, girders or pieces taking transverse strains?

Factors of safety varying from 4 to 10 should be used, depending upon the materials and other conditions.

INSPECTOR OF REGULATING, GRADING AND PAVING.

174. Name the principal pavements used in city streets.

The principal pavements are:
Asphalt (sheet and block), stone block (cobble, Belgian and granite), wood block, brick, and macadam.

175. Describe the characteristics of a first-class pavement for use in the city.

A good pavement should be impervious, hard, durable, noiseless and clean. It should afford a good foothold for horses, be adapted to all grades, and all classes of traffic. It should be cheap and easy to repair.

176. State what you understand by the term "regulating."

Regulating in highway construction refers to the operation of fixing lines and grades for the guidance of the workmen, and to define the limits of the work.

177. What do you understand to be the difference between materials classified as rock and those classified as earth in paying for grading jobs? How is the classification determined?

In grading jobs, materials are usually classified as follows:
Earth Excavation—which includes clay, sand, loam, etc., or these materials intermixed with boulders measuring less than 1 cu. yd.
Loose Rock—which includes all stone and detached rock in masses less than 3 cu. yd; also, slate and other rock that can be quarried without blasting.
Solid rock, which includes all rock found in place in ledges and masses which can only be removed by blasting.

178. Describe the steps of construction of a first-class pavement and street to take the place of a common dirt road.

The road is first surveyed and cross-sectioned, profiles prepared and grades established.
The cross-section is planned, showing the dimensions and character of the pavement and foundation.
The road is staked out, grade stakes being set at centre, curbs, house lines and slopes, with depth of cut or fill indicated.
The excavation for both curb and roadway is then made to subgrade. The bottom is drained, flushed, tamped, freed of all poor material (which is replaced with good soil or sand), and brought to

an even surface parallel to the finished paving. The curbs should then be set.

Upon the subgrade a layer of concrete is spread for the foundation, having its top surface parallel to finished pavement.

Upon the concrete is spread a cushion layer of sand or a binder layer of asphalt and stone, depending upon the kind of covering to be used.

Upon this the final and finishing layer of blocks or asphalt is laid.

The construction of the sidewalks proceeds at the same time and in substantially the same order.

179. Where a high embankment is to be made in grading a street, state (*a*) whether it makes any difference how the material is distributed, and if so what the rule is. (*b*) Give your reasons.

(*a*) The best way is to spread the fill in horizontal layers from 9 to 18 in. deep, flush each layer with water and compact by rolling with a heavy roller.

The method ordinarily followed is to complete the construction of the embankment to a certain height by dumping over the end, leaving same for a time to settle, and then depositing a second layer in the same way, and so on.

(*b*) The first method is the best because it reduces settlement of the embankment to a minimum. Settling of the embankment is injurious to the pavement and may cause its entire destruction.

180. State fully and clearly everything to be done in preparing the ground surface for and laying a telford road, with macadam surface.

The surface of the roadbed must be graded uniformly to a depth of 18 in. below the finished surface, and compressed by rolling. On this is laid a course of large, irregular-shaped stones about 10 in. deep, 6 in. wide and 15 in. long. The broadest edge is placed on the earth bed, and the wedge-shaped spaces between the stones are filled with smaller pieces and chips of stones. The projecting corners of the large stones are broken off with hammers. On the surface of the telford foundation a 4-in. layer of broken stones (not greater than 2½ in. in their largest diameter) is laid, sprinkled and rolled; dry trap screenings are rolled into the interstices of the broken stone; the top 4-in. layer of broken stones is then laid, no stones being greater than 2 in. in their largest diameter; this is sprinkled and rolled, until brought to the true grade. A surface coat of screenings is then applied, thoroughly soaked by sprinkling and worked into the interstices of the top layer by rolling with a roller of not less than 4 000 lb. to the foot of width.

181. State the essential points of a first-class stone block pavement.

1. Quality of the stones.—They should not be too hard or capable of taking any polish, and should afford good foothold for horses.
2. Size.—Depth should be about 7 in., width not more than 4 in., and length 9 to 12 in. They should be well squared.
3. Foundation.—Should be constructed of hydraulic cement concrete, 4 to 9 in. thick, depending upon the character of the traffic.
4. Cushion course.—A $\frac{3}{4}$-in. layer of sand, clean, dry and free from pebbles, should be spread over the concrete.
5. Laying.—Should start at the sides and proceed toward the center and the whole row keyed tightly. Joints should be broken and as narrow as possible. Blocks must be well rammed and low blocks removed and properly replaced.
6. Blocks should be laid in parallel courses at right angles to axis of street.
7. Joints should be filled with paving pitch and gravel and a layer of sand should finally be spread over the blocks.
8. At intersections the blocks should be laid diagonally or as usually called in the "Herring-bone" fashion.

182. Is it detrimental, in your opinion, to pave stones of different depth in the same row in a pavement, and if so, why?

Yes. If the stones in the same row are not uniform in depth they are liable to settle unequally under traffic, causing hollows and ridges, and eventually destroying the pavement.

183. In what way is poor work done by pavers in selecting and placing paving blocks?

1. By not placing blocks of a uniform width and depth in the same row.
2. By not ramming the blocks to a firm bearing and even surface.
3. By not breaking joints properly.
4. By not pouring the required quantity of paving pitch into the joints.

184. What is meant by "back-ramming" and what is its object?

The operation of ramming newly-laid blocks often causes blocks which have been previously rammed to loosen up slightly. "Back-ramming" refers to the operation of bringing these blocks back to firm bearing.

185. Describe in your own language a perfect paving brick, considering (*a*) its form, finish and dimensions; (*b*) the materials of which it is composed and its physical condition.

(*a*) "Standard" paving-bricks are 2½ by 4 by 8 in. They should be annealed, non-porous, close in texture, have clean, sharp edges and be uniform in size and appearance.

(*b*) The clay employed in the manufacture of paving-brick must be rich in silica, free from lime, and able to withstand without fusing a red heat for a sufficient length of time to render the bricks hard, homogeneous and impervious to water.

The physical properties of a good paving-brick are:

1. It is not acted on by acids.
2. It does not absorb more than $\frac{1}{600}$ of its weight of water in 48 hours' immersion.
3. It is not susceptible to polish.
4. It is rough to the touch, resembling fine sandpaper.
5. To give a clear, ringing sound when struck with another.
6. When broken, to show a compact, uniform, close-grained structure, free from air-holes and pebbles. Marked laminations are bad defects.
7. Not to spall, chip, or scale when quickly struck on the edges.
8. Hard, but not brittle.

186. Describe the construction of a first-class brick pavement.

The bricks should be of the best quality paving-brick, annealed and 2½ in. x 4 in. x 8 in. in size.

The street should be excavated to subgrade, all objectionable material removed and replaced by firm soil or sand, and the bottom watered and rolled, so that it will be parallel to the finished surface.

Upon this layers of gravel and sand or concrete and sand are spread for foundation and cushion courses.

The bricks are laid on the prepared bed of sand. They should be laid on edge at right angles to the axis of the street and break joints by 3 in. or more. No broken bricks should be permitted, except at closing points.

Before closing they should be compressed by iron bars and then keyed by close-fitting bricks. After 25 or 30 ft. of paving are completed, the bricks should be rammed with 50-lb. rammers and all low bricks removed and properly replaced.

The joints are then filled with sand, cement or paving pitch, and a layer of ½ in. of dry sand spread over the entire surface.

187. State all the points to be observed in laying an asphalt pavement over an old cobblestone pavement.

The surface of old pavement should be thoroughly cleaned by sweeping with stiff brooms until all dirt, etc., has been removed from the surface and from the joints to a depth of about 1 in.

The surface is then evened up and brought parallel to the finished grade by excavation if necessary, all depressions being filled with binder or concrete. Upon the blocks thus prepared a binder course is laid consisting of paving-pitch and $1\frac{1}{4}$-in. broken stone, 1 gallon to the yard. The surface of the binder is made parallel to the finished surface. The stone used in the binder should be heated. The wearing surface of asphalt is then laid and rolled upon the binder to the required thickness, and covered with a thin coating of hydraulic cement.

188. (*a*) What are the principal requirements in relaying asphalt pavements? (*b*) In relaying block pavements?

(*a*) In relaying asphalt pavements the sub-grade must be brought to a true surface, well rammed and free from all objectionable matter.

The foundation course of blocks or concrete must be carefully laid and bonded with the adjoining portions of the old foundation. The binder is then put on. It should also be well bonded with the adjacent portion of the old binder. In joining the old work with the new, the old must be cleaned and stripped of disintegrated or loose portions and in the case of concrete thoroughly wetted.

The wearing surface is then laid and well tamped with hot irons where it joins the old work.

The new surface is thoroughly rolled until it presents a uniform appearance with the old.

(*b*) In relaying block pavements the surface at sub-grade, as well as the concrete foundation and cushion coat, should be brought true and well tamped, so that when the blocks are rammed they will be firm and present an even surface without ruts or depressions. Sand must be used to adjust sub-grade when necessary. The blocks should fit properly and not work loose, and must be well bonded into the old pavement. The joints are then filled with pitch and gravel and a layer of sand spread over the new work.

189. (*a*) In preparation of the surface of concrete to receive binder or of binder to receive a subsequent coat of asphalt, name two essential things to be guarded against. (*b*) State why.

(*a*) No water or moisture must be present on the surface of the concrete or binder.

The surface of the foundation should not be left too smooth, so that a good bond will be secured.

(*b*) When the hot asphalt is applied to a damp surface, the water is immediately turned into steam, which tries to escape

through the heated material. As soon as the pavement is subjected to traffic, the fissures formed by the steam appear on the surface, and the whole pavement quickly falls to pieces.

If the asphalt pavement is not well bonded with the foundation it tends to slip under the action of traffic and roll up into waves.

190. Which would you consider the best finish to leave on the surface of a concrete bed for an asphalt pavement, that it should be smooth or left rough? State your reasons.

A slightly rough surface is better than a perfectly smooth finish, because it gives a better bond between the asphalt pavement and the concrete foundation, and it also prevents the slipping of the asphalt surface on the foundation.

191. (*a*) What is the proper temperature at which asphalt should be brought on the work? (*b*) What effects are produced by its being either too hot or too cold. State each.

(*a*) 250° F.

(*b*) If the asphalt is overheated it is decomposed and loses its adhesive qualities.

If the asphalt becomes too cold on the work it hardens and cannot then be worked to the correct shape of the roadway.

192. State how you can tell whether the paving-pitch has been overheated or not. What is the result of overheating on its wearing qualities?

If paving-pitch is overheated it becomes coked, in which condition it is brittle and useless.

193. State as nearly as you can the causes for (*a*) the formation of long cracks across an asphalt street. (*b*) The shoving up into waves. (*c*) The breaking up or wear in spots.

(*a*) Due to unequal contraction of surface asphalt and of binder in very cold weather; also to irregular settlement of foundation.

(*b*) Under extreme heat the asphalt is liable to become so soft that it will roll, or creep under traffic and present a wavy appearance.

(*c*) Usually due to the disintegrating effects of standing water.

Also due to carelessness in relaying pavement after it has been taken up. Fires on the streets will also cause bad spots in the asphalt.

194. (*a*) How may water affect an asphalt pavement after it is laid, and where is this effect most likely to occur? (*b*) State what is done to prevent this?

(*a*) Water, if permitted to remain upon the pavement, causes the asphalt to disintegrate. This effect is most likely to occur in the gutters.

(*b*) The gutters for a width of 12 in. next to curb must be coated with hot, pure asphalt, and smoothed with hot smoothing irons in order to saturate the pavement with an excess of asphalt; or the gutters may be constructed of paving-blocks well bonded into the asphalt.

195. (*a*) What is the least grade that is desirable for the gutters of a street? (*b*) Where the grade between two intersections is too flat, by what expedient may better grades be obtained without disturbing the cross-streets?

(*a*) The least gutter grade is about one-half per cent.

(*b*) Accommodation summits are put at the center of the main streets, thus giving them a slight fall towards the crossings and causing the water to flow in both directions from the summit.

196. What are the minimum and maximum allowable grades (*a*) for granite block pavement? (*b*) For asphalt pavement? (*c*) Wood? (*d*) Macadam?

	Minimum Grade.	Maximum Grade.
(*a*) Granite block........	1.5%	10% and over
(*b*) Asphalt	0.5%	$2\frac{1}{2}$%
(*c*) Wood................	0.7%	5%
(*d*) Macadam............	1.0%	5%

Grades outside of these limits are, however, occasionally employed.

INSPECTOR OF SEWERS.

197. What are the essential requirements in a well-constructed sewer?

A well-constructed sewer—

1. Must have a solid foundation.
2. Must be laid to true line and grade.
3. Must have a velocity of flow sufficient to prevent settlement, but not high enough to cause "scour."
4. Must be constructed water-tight.
5. Must have manholes at summits and valleys and at all changes of direction, and enough lamp-holes to permit thorough examination.
6. Must be laid below frost line and low enough to take the waste from all houses along its route.
7. The outlet must be carried to a point where it will not cause a nuisance, or be a menace to health.

198. Describe (*a*) your inspection of bricks delivered on the work for a sewer; and (*b*) the only right way of laying the same to insure tight work.

(*a*) The bricks must have the proper color, and be free from cracks or flaws. No bats are to be used. The bricks must be culled upon delivery on the ground; the inspector should immediately send samples, selected at random, to the laboratory for such tests as he cannot make on the ground. A brick should not absorb more than about one-tenth of its weight of water, should emit a clear, ringing sound when struck a sharp blow, and when broken should show a compact, uniform structure, hard and somewhat glassy, and be free from air bubbles, cracks, cavities and lumps.

(*b*) Every brick is required to be laid in full mortar joints, on bottom, sides and ends, which for each brick is to be performed in one operation.

199. Outline specifications for building a brick sewer.

The bricks shall be of best quality, hard-burned, free from cracks, and have true, even faces.

They must be thoroughly wet before laying.

Each brick must be laid in full mortar joints on bottom, sides and ends, which must be performed in one operation.

Hydraulic cement mortar should be used.

No mortar is to be worked in after brick is laid.

Joints should not exceed $\frac{3}{8}$ in. in thickness.

Brickwork should be properly bonded and arches keyed.

Cement and sand should be of proper quality and properly mixed.

The mortar should be used right after mixing; no mortar which has begun to set should be used.

No work should be done in freezing weather.

Every second course should be laid with a line.

The foundation must be firm and unyielding.

Centres must be of proper form and dimensions and proper care observed in "striking" same.

200. What is the best bond for brick sewers?

The best bond is the rowlock bond, which consists of concentric rings, each longitudinal course breaks joints with the adjacent courses and with the rings above and below. All bricks are laid as stretchers.

201. Where are headers used in a circular brick sewer and why are they so used?

Most specifications prohibit the use of headers in brick sewers, especially in the upper or arched portion. In large brick sewers, however, where three or more rings of brick are used, the rings are laid alternately as headers and stretchers with such modifications as are necessary to secure a perfect bond.

202. Describe the proper method of keying a brick arch.

The usual specification is as follows:

In keying the arch no headers are to be used. The inner and outer courses of stretchers are to be carried over and keyed separately, and each course in the crown of the arch is to be thoroughly grouted.

203. How and when should centres be struck?

Centres should not be struck before the mortar has had ample time to set. They should then be struck so as to bring the pressure uniformly upon the arch.

204. What are the rules governing the insertion of spurs in brick sewers, as to location, direction, etc.?

Spurs are usually spaced about 12 ft. 6 in. along the sewer pointing alternately towards house lines or opposite sides of street; this gives one spur for each 25-ft. front lot. The spurs must enter near the top of the sewer section and point in the direction of the flow.

205. Describe alteration in line of a large brick sewer and method of caring for the flow meanwhile.

The sewer is first built along the new line, and when ready to join on to the old work a bulkhead of brick or cement bags is built at the points where the change of line begins and ends, the arch between the points having already been removed. A temporary flume (or flumes) of sufficient size to carry the greatest flow, having the ends built into the bulkheads, is suspended or supported in the line of the old sewer, and far enough above the old invert to permit the construction of the new invert at the points of connection. The old invert is now removed, the new work built and the connections made, after which the bulkhead and flume are removed and the flow turned into the new sewer.

206. Outline specification for back-filling subway near adjacent sewer.

Filling should consist of sand, gravel or good, clean earth free from stones over 8 in. in diameter and not containing more than one portion of stone to three of earth. It should be deposited in layers not more than 9 in. thick, watered and packed by rammers weighing not less than 30 lb., and in such manner that no unbalanced pressure can be thrown upon subway or sewer. Filling must be carefully packed and rammed about sewer, using special tools. No filling should be made with frozen earth. Sheeting should be carefully withdrawn as fast as filling progresses or may be left in place.

207. In building a large sewer where quicksand is encountered (*a*) how would you proceed to get sound work? (*b*) Under what conditions does quicksand of itself make a good foundation?

(*a*) In excavating for the foundation the width of the trench should be 2 to 4 ft. more than is required for the masonry. The sides should be very strongly braced by sheeting. Double wall linings should be used and provided with a cutting edge at the bottom, strongly braced between walls and filled with clay and sand. The excavation should proceed under the cutting edge, leaving a core at the center which is gradually removed with the sinking of the lining until a good foundation is secured. The excavation can be facilitated by forcing cement grout into the quicksand, solidifying the mass, or freezing the mass by the usual freezing process. When the proper depth is reached piles may be driven with butt end down into the underlying strata to solid bearing and the sewer built on the piles in the usual manner.

(*b*) When quicksand is so confined and drained as to prevent flowing or displacement of same, it will make a safe foundation.

208. How frequently should catch-basins be placed along a street, and what rule governs this? How frequently should manholes be placed?

Catch-basins should be placed at all low points in the street where considerable water is apt to collect. On long grades catch-basins are placed at every street intersection where the grades permit.

Manholes should be placed every 100 ft. for small sewers; for large sewers this distance may be from 200 to 500 ft., depending upon their size. They should be frequent enough to permit cleaning and afford proper ventilation for the sewers.

209. What is a flush-tank and what are its uses?

A flush-tank is a device for periodically flushing a sewer by automatically and rapidly discharging a large quantity of water into it. It is usually placed at dead ends of sewers, where material is apt to collect.

It is an essential feature of the separate system in which no storm water is permitted to reach the sewers. The water for operating the tank is supplied by the regular mains.

210. It is necessary to rebuild 100 ft. of a 48-in. brick sewer with considerable flow of water through it; describe completely the operation.

The top of the sewer is first removed. To take the flow during construction, a flume is built at the bottom of the sewer starting a little beyond each side of the 100-ft. length which is to be rebuilt. The sides and bottom of the sewer are now removed, the flume being firmly supported at all stages of the operation. The construction of new foundation and the lower half of the sewer is then proceeded with; after the brickwork has set the flume is removed so as to divert the regular flow into the new invert, and the upper half of the sewer is completed.

211. Describe the rules that must now be observed in laying pipe sewers.

The pipe must be laid true to grade and line, and each length properly bedded. A recess must be cut in the bottom of the trench to receive the socket of the pipe.

The spigot-end of each pipe must be properly entered and sent home into the socket of the adjoining pipe.

The gasket of hemp or oakum must be properly used. The socket should not be filled with it to the exclusion of the mortar.

The joints must be carefully filled with cement mortar all around.

Spurs must be closed with suitable stoppers if not to be used immediately.

The backfilling must be carefully done; no stones should be used for filling within one foot of the pipe, and the material must be tamped with suitable tampers to insure compactness.

212. Describe in detail the method of laying a 30-in. cast-iron pipe.

The trench should be dug 4½ ft. wide, and at joints deep enough to permit access for caulking. Two blocks and four wedges are then laid on line a little below grade of pipes. The pipes are rolled over the trench, raised by a derrick and lowered into position, bells facing up hill. They are then raised to true grade by means of the wedges; the spigots should be entered well into the bell and be concentric with same. The gasket of oakum is driven into the annular opening, leaving about 3 in. for the lead. The lead is run in one operation so as to leave a projecting bead which is driven in by caulking, making perfectly tight joints.

213. Suppose the top of the grade stake set at one end of a 25-ft. length of sewer was 13 ft. 3 in. above grade, and at the other end 11 ft. 7 in. above grade; how would you fix grade line?

Upon the stake whose top is 13 ft. 3 in. above grade, mark a point 2 ft. 3 in. below top; also mark a point 7 in. below the top of the other stake. A string stretched taut between the points thus marked will be parallel to, and 11 ft. above grade. Points on grade are readily obtained by measuring down 11 ft. from the string.

214. Describe a good job of tamping earth around a sewer, giving best arrangement of men and other requirements.

The trench should be filled with layers not exceeding 4 in. thick in the loose, and the earth used is not to be dumped in piles, but is to be spread evenly and compressed by iron tampers. The number of men using tamping irons should be in the proportion of four tampers to one shoveller. In case of pipe sewers, special precautions are necessary. The earth must be carefully laid in, tamped, and solidly rammed down, under and around the pipes, with proper tools made for this purpose.

215. How soon can filling-in be done about a pipe sewer? What governs this?

The back-filling should not be commenced in the case of a pipe sewer until the cement joints have hardened sufficiently.

216. How much clearance in a trench should be allowed each side of a sewer to obtain good work?

One foot.

217. Under what conditions would you think it desirable to leave the sheeting in a trench and why?

In soft ground the lower course of sheeting should not be removed after the arch of the sewer has been built, as the arch is liable to crack if uneven settlement of the material above takes place.

218. Of what are soil pipes constructed and where trapped?

All mains, soil, waste or vent pipes must be constructed of iron, steel or brass. Soil pipes when connected with any fixtures must be trapped before entering the sewer and the trap so arranged that it can be reached for cleaning and be protected from frost.

219. Why should traps be connected with vent pipes?

To carry off any gases collecting in the traps, and insure proper ventilation. Otherwise the gases might force the seal in the traps and work back into the house.

220. What kind of traps may be used? What are their sizes and how set?

Only water-seal traps may be used with a seal of at least $1\frac{1}{2}$ in. They must be well supported and set true with regard to their water level. The discharge from any fixture must not pass through more than one trap before reaching the house drain.

221. When shall sewer connections be made?

The connections should be made before the walls are carried above the foundations.

222. What do you understand a fresh-air inlet to be for?

It is used to furnish fresh air to the house drain just inside the house trap. It should extend to the surface or into a box and have a return bend.

MANUAL OF EXAMINATIONS

FOR

ENGINEERING POSITIONS

IN THE

SERVICE OF THE CITY OF NEW YORK

QUESTIONS AND ANSWERS
IN THREE VOLUMES

VOL. I. AXEMAN, CHAINMAN AND RODMAN, LEVELER, TRANSITMAN AND COMPUTER
VOL. II. ASSISTANT ENGINEER
VOL. III. DRAFTSMAN AND INSPECTOR

APPENDIX

EXAMINATIONS FOR CIVIL ENGINEERING POSITIONS

IN

FEDERAL, STATE AND MUNICIPAL SERVICE OUTSIDE OF THE CITY OF NEW YORK (INCLUDING PANAMA CANAL AND UNITED STATES NAVY)

INDEX

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GENERAL APPENDIX I.

CIVIL SERVICE OF THE UNITED STATES—GENERAL INFORMATION AND PREVIOUS EXAMINATION PAPERS.

INTRODUCTORY.

In order to increase the range of usefulness of the "Manual of Examinations for Civil Engineering Positions in the City of New York" and answer the many queries that have come to the publishers in reference to Civil Service outside the city, the following appendix is introduced. The appendix gives the examination requirements, previous examination papers, and number of positions open wherever obtainable. The examination papers include the Federal Service, United States Navy, New York State, Boston, Chicago, and other important cities. It is hoped that the collection of previous examination questions will prove useful to instructors and students in Technical Schools and to Civil Service Examiners, as well as to applicants for Civil Service positions.

Interleaving has been introduced to provide space for notes, sketches and additions.

The publishers will appreciate the receipt of Examination Papers, etc., not included in this compilation, from Civil Service Authorities and others for use in future editions.

OPPORTUNITIES FOR ENGINEERING GRADUATES IN THE SERVICE OF THE FEDERAL GOVERNMENT.*

The civil service of the government is a vast organization, including more than a quarter of a million people.

There are about 2 600 opportunities for engineering graduates in the government service, excluding West Point, the Isthmian Canal, and positions paying less than $700 per annum. For 46 per cent. of these positions the pay is between $700 and $1 400 per year; for about 32 per cent., from $1 500 to $1 900; for 18 per cent., $2 000 to $2 900; for three per cent., $3 000 to $3 900; and for nearly one per cent., $4 000 or over. These figures are for salary only, they do not include allowances for expenses, subsistence and quarters furnished, etc., which are received by many.

There are nearly 700 opportunities under the Chief of Engineers of the army for engineering graduates. This force includes 180 assistant engineers or superintendents, 150 junior engineers, and 70 draftsmen. The lake survey is a part of this group of 700.

There are more than 500 opportunities in connection with navy yards and naval stations. This includes 40 civil engineers and constructors, and nearly 400 draftsmen.

In the engineering force of the Reclamation Service, under the Geological Survey, there are 360 engineers. This service is growing very rapidly and will probably continue to do so for several years. Hence, it furnishes the best chance in the government service for the rapid advancement of unusually able men, with the possible exception of the Panama Canal work.

Three hundred patent examiners are employed in the Patent Office.

In the Coast and Geodetic Survey there are 130 opportunities for engineering graduates; 90 in the field force, 20 as draftsmen, and 20 as computers.

There are 130 opportunities under the General Land Office.

The remaining 500 opportunities are scattered through the service. The largest groups are in the Topographic Branch of the Geological Survey, in the Revenue Cutter Service in charge of marine engines, under the Supervising Architect as superintendent, and in the engineer department of the District of Columbia.

New appointments are being made at the rate of about 200 per year to repair the waste in the force of 2 600, and to produce the steady expansion which is normally in progress.

Nearly all of the 2 600 positions are in the classified service, to which entrance is guarded by the Civil Service Commission and

* From Vol. XIII, Proc. Soc. for the Promotion of Engineering Education.

from whom full information concerning the examinations may be obtained.

For many examinations, especially examinations requiring technical qualifications, the Civil Service Commission distributes special printed announcements about one month in advance of the examination. Any professor of engineering may have all such announcements, covering specified lines, sent to him regularly merely by making a request in writing to that effect. The student, or graduate, may also, as an individual, apply for these announcements and receive them as they appear.

Do not write for an application blank for an examination which has not yet been officially announced.

By using the manual and annual report and the special announcements of examinations, the professor of engineering may keep in close touch with nearly all the opportunities for appointment of his graduates to the classified civil service, except the following two large classes.

First, the five hundred positions which have been referred to in connection with the navy yards and naval stations are filled by examinations held under the direction of the Navy Department, not the Civil Service Commission. Many of these examinations are advertised and held only in the locality in which the appointment is to be made. Information in regard to these examinations must be obtained at the Navy Department at Washington, or from the officers having local charge of the work.

Second, there are two methods of entrance to the position of junior engineer under the Chief of Engineers; namely, by a civil service examination, known as the "civil engineer, departmental service" examination, and by promotion from lower grades in the service, under the Chief of Engineers, such, for example, as inspector, recorder, transitman, levelman, rodman, or chainman. Appointments are made to these lower grades from registers of eligibles established at various points by local boards of civil service examiners, without examination. Any employee may be promoted from one of these lower grades to the grade of junior engineer on the recommendation of his employing officer, provided he passes the appropriate examination held under the direction of the Civil Service Commission. If he holds a diploma of graduation in an engineering course from an approved technical school he may, after one year's service, be so promoted without examination. This is the class to which your attention is especially called. For more complete data apply to the Chief of Engineers for the circular known as "information concerning positions under the engineer department at large."

Information in regard to rates of promotion, prospects of promotion, character of service required, and the conditions of service, must, in general, be obtained from the different bureaus or depart-

ments concerned in much the same way that it is obtained in regard to positions outside the government service; that is, by correspondence or personal acquaintance with those in charge or with the employees. Such information cannot, except to a limited extent, be obtained from the Civil Service Commission.

Promotions in the government service are made on merit. Merit is, as a rule, ascertained in much the same manner as in any large organization, by observations of the employee's work by his official superiors. It is placed on record by the recommendations of those superiors.

In the Reclamation Service, such recommendations are all placed twice a year in the hands of a committee of three men of high rank in the service who have a wide acquaintance with the personnel. This committee virtually decides what promotions shall be made, subject, of course, to approval. A similar system is in force in the Geological Survey as a whole.

Under the Chief of Engineers, promotions from junior engineer to assistant engineer depend upon recommendations by the official superiors, but are also subject to two conditions. The candidate must, at some time, have passed the civil engineer examination before the Civil Service Commission, and he must possess the professional qualifications that are required for full membership in the American Society of Civil Engineers. In general, an assistant engineer is selected from among the junior engineers in the district in which he is to serve. That is, the civilian employees in general stay in a given district on the work with which they are familiar, though the officers of the Corps of Engineers, under whom they serve, are periodically transferred from station to station.

As a rule, any attempt on the part of a government employee to bring political influence to bear to secure a promotion is interpreted as a confession on his part that he does not feel that he has sufficient merit to warrant promotion. The confession is apt to be taken at face value. Such confessions are rare.

INFORMATION RELATIVE TO EMPLOYMENT IN THE PHILIPPINE CIVIL SERVICE.*

Opportunities.—The civil service of the Philippine Islands offers excellent opportunities to qualified persons, both in the matter of salary and promotion. Under the operation of the civil-service law promotions may be made on the basis of merit from the lowest to the highest positions, and the records of that service indicate that qualified appointees have been rapidly advanced.

Age Limits.—The age limits for the service are 18 to 40 years unless otherwise expressly stated.

* Extract from Rules of U. S. C. S. Comm.

PHOTOGRAPHS AND MEDICAL EXAMINATION REQUIRED.—Each applicant for the Philippine service will be required to submit to the examiner, on the day he is examined, a recent photograph, taken not more than three years ago, of himself, which will be filed with his examination papers as a means of identification in case he receives appointment. An unmounted photograph is preferred. The date, place, and kind of examination, the examination number, the competitor's name, and the year in which the photograph was taken should be indicated on the photograph.

The medical certificate in Form 2 must be filled in by some medical officer in the service of the United States. Special arrangements have been made with pension examining boards throughout the country to give such examination for a fee of $2, to be paid by the applicant. If such boards can not be conveniently visited, applicants should appear before medical officers of the Army, Navy, Indian Service, or Public Health and Marine-Hospital Service.

The medical officer should indicate his rank or official designation on such certificate.

TRANSFERS.—Under a recent amendment to the Federal civil-service rules, employees who have regularly served for three years in the Philippine civil service are eligible for transfer to similar positions in the Federal service.

CLIMATE.—The climate is good, and nearly all the employees are in excellent health. There is continuous warm weather in the Philippines, but the heat is not intense, and the general health of American civilians who take reasonable care of themselves is good. During the greater part of the year Americans suffer less from the heat than during the summer months in many parts of the United States. From April to July is the hottest period. From July to October there are frequent rains which cool the atmosphere, and from about the middle of November to the middle of March the weather is, as a rule, clear and pleasant. The nights during this period are cool; in fact, the nights are generally pleasant during the whole of the year, with the exception of possibly two or three months. It may also be stated that China and Japan are near at hand and are favorite places to visit during vacations. Within twelve hours' travel of Manila, in the province of Benguet, where it is understood the summer capital is to be located, the climate is cool, and as the province is convenient and easily accessible it affords an excellent place at which to seek recuperation.

CLOTHING.—Americans usually dress in white drill suits. Those who go to the Philippines will find it to their financial advantage to wait until they reach Manila before purchasing any clothing for use in that climate. Serviceable white cotton drill suits are made to order in Manila for about $3 each. Heavier clothing, adapted to the climate at times, can also be purchased at very reasonable prices.

Medical Attendance.—At present medical attendance is furnished to employees in Manila without cost. A civil hospital has been established in Manila, to the wards of which civil-service employees are admitted at a uniform charge of $1 a day, with medical and surgical attendance, medical supplies, nursing, and food included. Those who desire private rooms are required to pay from $10 to $20 a week.

Cost of Living.—Those who live outside of Manila can live fairly well for $30 or less a month. In Manila the cost to employees is determined largely by the manner of living. Many who rent rooms and live in "messes" keep their living expenses in the neighborhood of $35 to $40 a month. The better hotels charge about $40 to $50 a month, while the best hotels are higher in their rates. A civil commissary has been established, the advantages of which are available to civil-service employees in the provinces, but not in Manila. The large number of dwellings now being erected warrants the prediction of a material decrease in rents during the year. An electric street railway throughout the entire city of Manila is nearing completion. This will do away with the expense of cab transportation. It will also materially reduce rents by permitting the population to scatter over a wider area, and will make life pleasanter and cooler and cost of living cheaper.

Leave of Absence.—After at least two years' continuous, faithful, and satisfactory service, the civil governor or proper head of a department shall, subject to the necessities of the public service, and upon proper application therefor, grant each regularly and permanently appointed officer or employee in the civil service, insular or provincial, or of the city of Manila, except as hereinafter provided, accrued leave of absence with full pay, inclusive of Sundays and of days declared public holidays by law or Executive order, for each year of service in accordance with the following schedule: An employee receiving an annual salary of less than $600 shall be granted twenty days' leave; an employee receiving an annual salary of from $600 to $900 with board and quarters, and an officer or employee receiving an annual salary of $900 or more, but less than $1 800, shall be granted thirty days' leave; an officer or employee receiving an annual salary of $1 800 or more shall be granted thirty-five days' leave. Leave shall accrue while an officer or employee is on duly authorized leave of absence with pay. In addition to the leave mentioned, an employee receiving less than $1 000 a year may be granted 21 days' vacation leave, and an employee receiving $1 000 a year or more may be granted 28 days' vacation leave during each calendar year. This vacation leave is in lieu of any leave of absence on account of sickness.

Transportation.—A person residing in the United States who is appointed to the Philippine civil service may pay his traveling

expenses from the place of his residence in the United States to Manila: *Provided,* That if any part of his traveling expenses is borne by the government of the Philippine Islands, 10 per cent. of his monthly salary shall be retained until the amount retained is equal to the amount borne by the government: *And provided further,* That if he shall come by the route and steamer directed, his actual and necessary traveling expenses shall be refunded to him at the expiration of two years' satisfactory service in the Philippines.

He shall be allowed half salary from the date of embarkation and full salary from the date of his arrival in the islands: *Provided,* That he proceed directly to the islands; otherwise he shall be allowed half salary for such time only as is ordinarily required to perform the journey by the route directed: *And provided further,* That such half salary shall not be paid until after the expiration of two years of satisfactory service in the Philippines.

A person residing in the United States accepting an appointment to a position in the civil service of the government of the Philippine Islands shall, before receiving such appointment, execute a contract and deliver it to the chief of the Bureau of Insular Affairs, War Department, wherein the appointee shall stipulate that he will remain in the service of the government of the Philippine Islands for at least two years, unless released by the civil governor or proper head of a department. A breach of the conditions provided in the contract or a removal for cause shall require the proper officer to withhold payment of all salary and traveling expenses due to the person employed and who has violated the conditions of his contract or been removed for cause, and shall debar such person from ever entering again the public service of the Philippine government in any of its branches. In such case an action shall lie for the recovery of the amount expended by the Government in bringing the employee to the Philippine Islands.

No arrangements have been made for holding examinations for ordinary clerical positions in the post-office, custom-house, and internal-revenue services and trades positions in the Philippines. Such positions are usually filled by the appointment of Filipinos. Application should be made to the Philippine civil-service board at Manila, P. I., for information concerning appointment to these positions.

INFORMATION CONCERNING CONDITIONS OF EMPLOYMENT IN THE ISTHMIAN CANAL SERVICE.

For the further information of applicants and others, the following statement is published relative to conditions of employment on the Isthmus of Panama under civil service rules by the Isthmian Canal Commission.

General Conditions on the Isthmus of Panama.—Representatives of the Civil Service Commission who have recently returned from Panama report that conditions have greatly improved on the Isthmus. The health of the employees is excellent. On April 11, 1906, less than two per cent. of the American employees were on the sick list. While there have been some cases of yellow fever since the Americans occupied the Isthmus, there has not been a single case since last November, which is due to the sanitary measures taken by the authorities. Substantial meals are furnished in the hotels erected for employees at 30 cents a meal, and comfortable quarters have been erected and are in course of erection for married men and their families and for bachelors. As higher salaries are paid than in the United States, it is practicable for employees to save a large proportion of their salaries. Employees on the Isthmus freely express their appreciation of the work done by the Government in providing for their material welfare, and there is a spirit of coöperation and contentment throughout the service.

The winter months on the Isthmus are, as a rule, clear and pleasant. During this period the nights are cool, which is also true of the nights during the summer months. While there is continuous warm weather, the heat is not intense. The quarters provided for employees are in cool places near the seacoast, or on the higher elevations, and it is believed that Americans on the Isthmus suffer less from heat than they do during the summer months in many parts of the United States.

Employees Whose Salaries are Fixed on a Monthly or Annual Basis.—The salaries of such employees begin upon the date of embarkation at port of departure from the United States, but no payment on account thereof shall be made until after thirty days' service on the Isthmus. They will be required to pay all expenses of the journey to the port of departure, which expenses will not be refunded, but they will be granted free transportation from that port to the point of destination, which will include meals on the steamer. Where practicable and in the best interests of the service they will be provided with such quarters on the Isthmus as may be available from time to time, and if such quarters are not available they will be granted, in lieu thereof, a sum, payable monthly, equal to 15 per cent. of their monthly compensation.

They may be granted, in the discretion of the head of the department in which employed, leave of absence at the rate of six weeks for every twelve months of service rendered, such leave to be cumulative for a period of two years and to be granted at any time after eight months' service in the discretion of the head of the department in which employed. If such leave is granted, they will be entitled to the Government rate of $20 each way on the steamers of the Panama Railroad and Steamship Company operating between New

York and Colon. This grant of a leave of absence is not to be considered a vested right, but is made to promote the welfare and interests of the service, and compensation for the period of their leave will not be paid until after their return to duty.

In the event of illness an employee may be granted, upon the certificate of an authorized physician of the health department in the Canal Zone of his disability for work, sick leave with pay, in addition to such other leave of absence as may be granted to him, such sick leave with pay continuing during disability not to exceed thirty days in any calendar year for an employee appointed in the United States whose salary is fixed on a monthly or annual basis, and not to exceed fifteen days in any calendar year for an employee appointed on the Isthmus whose salary is fixed in like manner. Such leave of absence on account of illness shall not be cumulative.

Employees whose salaries are fixed on a monthly or annual basis will receive no extra pay for overtime work required of them.

Medical Attendance.—Free medical and hospital attendance in case of illness is provided.

Return Transportation.—Free transportation is provided to a port of the United States upon the termination, by or at the instance of the Isthmian Canal Commission, of satisfactory service, the character and length of such service to be determined by the head of the department in which employed.

Transportation of Families.—Members of the immediate families of employees will, upon request, when the exigencies of the steamship service permit, be granted the Government rate of $20 between New York and Colon. No charge will be made for children under 6 years of age, and half rates will be charged for children between the ages of 6 and 12 years. Employees will not be permitted to take their families to the Isthmus until they have gone there first and secured quarters for them.

Assignment of Duties.—The assignment of duties is vested in the head of the department in which employed, and employees are expected to perform such duties as may be assigned them by competent authority. Services must be satisfactory to the head of such department.

Each applicant for the Isthmian Canal Service will be required to submit to the examiner, on the day he is examined, a photograph of himself, taken within three years, which will be filed with his examination papers as a means of identification in case he receives appointment. An unmounted photograph is preferred. The date, place, and kind of examination, the examination number, the competitor's name, and the year in which the photograph was taken should be indicated on the photograph. The medical certificate in the application is also required.

No person will be appointed for service on the Isthmus who is

not physically sound and in good health. Persons examined for positions on the Isthmus will not be eligible, as the result of such examination, to positions in the United States or Philippine services. Persons appointed will be expected to proceed promptly to the Isthmus of Panama.

Eligibles selected for appointment in this service will be subjected to rigid scrutiny and may be physically reëxamined upon reaching the port of embarkation for the Isthmus, and will be rejected if the statements in the application are found to be false or incorrect in any essential particular.

RATING OF EXAMINATION PAPERS.

METHOD OF RATING.—The following method is observed in rating examination papers by the Commission:

After an examination is held the papers are arranged by sheets or subjects and are forwarded under seal to the Commission. When they are reached in the order of rating, they are distributed by sheets to the examiners, Examiner A being given all of sheets 1, Examiner B all of sheets 2, Examiner C all of sheets 3, and so on, the sheets being distributed to as many examiners as there are subjects in the particular examination to be rated. After the papers are rated in the first instance they are redistributed, and the first rating is reviewed by other examiners. When all of the papers of an examination have been rated and reviewed, those of each competitor are then for the first time assembled or brought together, his average percentage is ascertained, his declaration envelope is opened, and the declaration sheet to which he has signed his name is attached to his examination papers. The identity of the competitor, therefore, is not disclosed *until his papers have been rated and reviewed and his average percentage determined.* As the charges for specific errors are all fixed by the rules for rating, and as each subject is rated by one examiner and reviewed by another, it will be seen that absolute impartiality, accuracy, and uniformity are secured in the work.

PREVIOUS EXAMINATION PAPERS.

AID, COAST AND GEODETIC SURVEY.

The position of deck officer will also be filled from this examination. Age limit, 18 to 25 years; application form, 1312; time allowed, two days of six hours each. The first three subjects will be given on the first day and the remaining subjects on the second day. The medical certificate on the application form must be executed by a medical officer of the Public Health and Marine-Hospital Service, except when this requirement would work a hardship upon an applicant because of his distance from such officer he may have the certificate executed by any physician, in which event, however, he may be required to pass a physical examination before an office of the Public Health and Marine-Hospital Service before appointment. Subjects of examination and relative weights of subjects on a scale of 100: Mathematics: Including geometry (plane and solid), algebra, trigonometry, and the elements of calculus, 15; Practical computations: Involving the use of logarithmic tables, 15; Astronomy: Elementary questions in spherical and general astronomy, with special reference to determination of latitude, longitude, and azimuth, and use of field instruments, 10; Physics: Elementary questions in optics, magnetism, etc., 10; Surveying: Elementary questions in plane and geodetic surveying, and use of field instruments, 10; Modern languages: Competitors may select one of the following: French, German, Spanish, Italian. Extracts of about 100 words are given for translation into English, 10; Drawing and Descriptive Geometry: A short test in topographic drawing and lettering is given with elementary questions on the principles of projection, 10; Training and experience rated on application form, 20.

The supply of eligibles for this position has not been equal to the demand.

AID, COAST AND GEODETIC SURVEY.

Mathematics.

[Logarithmic tables will be furnished.]

1. What angle does $\frac{1}{16}$ of an inch subtend at a distance of 1 000 ft.?

2. State the sum of the interior angles of a closed plane figure bounded by straight lines. Give proof.

3. What is the differential of the sine of an arc? Show geometrically its signification, and, by a practical example, the use of the result.

4. Compute all parts of a triangle having given angle A 33° 0′ 10″, angle B 45° 0′ 20″, and side AB 1 000 meters.

5. Describe the difference between the orthographic, stereographic, and different kinds of conic projections, and the advantages of each where they are employed. Explain generally the methods of descriptive geometry, and illustrate by an example.

Astronomy.

1. State the different methods of determining latitude, longitude, and azimuth, and compare their relative accuracy.

2. Give the adjustments of the transit instrument, and explain the method of making each.

3. Derive the azimuth factor, and show how it is applied in the reduction of meridian observations.

4. State approximately at what o'clock Alpha Lyræ (right ascension 18h. 33m.) comes to the upper meridian on April 26, and give the reasoning.

5. Can the southern cross, declination 62° south, be seen from the United States? Give the reasons for your answer.

Physics.

1. Name three processes by which heat is diffused.

2. What is the pressure in grams of the atmosphere on a square meter of the earth's surface at sea level, assuming the density of mercury to be 13.6? Give work in full.

3. What is meant by the C. G. S. system of units?

4. The periods of vibration of two pendulums are as 2 to 3; what is the ratio of their lengths?

5. What is an achromatic lens? What is an aplanatic lens?

6. Give a rough method of getting the magnifying power of the telescope of a surveyor's transit.

7. What is meant by the index of refraction of a substance?

8. Name the three elements of terrestrial magnetism which are usually determined by a magnetic survey.

9. Define agonic line.

10. What is meant by diurnal and what by secular variation of the magnetic needle?

Surveying.

1. Mention one method by which the size and figure of the earth can be found, and another by which its figure can be deduced.

2. Describe, briefly, two different kinds of apparatus suitable for measuring a base line.

3. What is meant by the reduction to sea level of a measured distance, and why is such a correction applied?

4. What is meant by "spherical excess," and when is it necessary to take it into account?

5. When does the sum of the azimuth and back azimuth of two intervisible stations differ from 180°?

6. A level has a scale value of 5 seconds to a millimeter; what is its approximate radius of curvature?

7. What is meant by the adjustment for "wind" in a level?

8. Represent a conical hill by six contour lines.

Geography of the United States.

1. Give the approximate geographical limits, by degrees of latitude and longitude, of the United States, and its approximate area.

2. Name the States touched by the Mississippi River.

3. Bound Illinois and Georgia.

4. Name five of the principal rivers emptying into the Atlantic.

5. Give the heights of the five highest mountain peaks in the United States, and their location, excluding Alaska.

Modern Languages.

Make a close translation of any two (and only two) of the following languages into idiomatic English:

French.—Au lieu d'enfoncer le tube dans le mercure, on peut le soulever de manière que son extrémité inférieure soit légèrement au-dessus de la surface du mercure. Comme il ne se produit plus alors une fermenture hydraulique l'élévation du niveau est presque imperceptible. Si, dans cette position du tube, on place l'anode à son intérieur, on constate naturellement un abaissement du niveau dont

la valeur est plus forte que celle de la précédente élévation. Ce résultat est dû à la différence des dimensions du tube et du vase. Dans cette dernière expérience, on peut évidemment remplacer le mercure par un métal solide; mais on remarque alors qu'il ne se produit aucune variation de niveau.

German.—Entfernt man sich in der Äquatorebene mehr und mehr und mehr von der Erde, so nimmt die Anziehung ab, die Zentrifugalkraft dagegen zu, bis endlich an einer Stelle Gleichheit eintritt. Darüber hinaus überwiegt die Zentrifugalkraft. Man kann nun diejenige Niveaufläche, in deren Äquator jene Gleichheit statt hat, als äusserste Niveaufläche bezeichnen, insofern sie unter gewissen Voraussetzungen die Grenze der Atmosphäre sein muss. Wir betrachten hier übrigens diese Fläche nur zu dem Zwecke, um an einem Biespiel zu erkennen, wie sich die Niveauflächen bei grösserem Abstande von der physischen Erdoberfläche verändern.

Spanish.—Si caen los cuerpos abandonados á sí mismos, es en virtud de una fuerza atractiva que los dirige hácia el centro de la tierra, y no por su propia espontaneidad; si disminuye gradualmente la velocidad de una bola en una mesa de billar, es por efecto de la resistencia del aire que desaloja, y por el roce sobre el tapete. Por consiguiente, de esto no debe deducirse que la bola tenga más bien tendencia al reposo que al movimiento, según decían algunos filósofos antiguos, que comparaban la materia con una persona perezosa. No habiendo resistencia, sigue sin alteracion el movimiento, como nos lo demuestran los astros en su revolucion al rededor del sol.

Italian.—I fenomeni di attrazione e di repulsione notati, possono venire indicati schematicamente come ora dirò. La fig. 2 rappresenta il caso in cui il filo A, visto in sezione, è unito metallicamente dal di fuori del tubo di scarica col catodo C. Sulla parete fluorescente si ha allora una zona M in ombra, la quale è molto più larga dell' altra mn che si avrebbe se A fosse neutro. I raggi catodici, che in questo caso sarebbero sensibilmente rettilinei, sono invece indicati in figura con delle linee di sensibilissima curvatura.

ASSISTANT EXAMINER, PATENT OFFICE, DEPARTMENTAL SERVICE.

Age limit, 20 years or over; application forms, 304 and 375; time allowed, two days of seven hours each. The first three subjects will be given on the first day, the remaining subjects on the second day. Entrance salary, $1 200. A credit not to exceed 15 per cent., and in no case to raise the competitor's grade above 100 per cent., will be given to competitors who have had actual experience in work similar to that required of assistant examiners in the Patent Office.

Subjects.	Weights.
1. Physics	20
2. Chemistry, inorganic and organic	20
3. Mathematics	10
4. Technics	20
5. Mechanical drawings	20
6. French or German (translations into English).	10
Total	100

The following questions and tests, which have been used, indicate the general character of the examination:

Physics.

1. A body whose mass is 10 grams, supported by a smooth plane inclined to the horizon at an angle of 30°, is connected by a cord passing over the head of the inclined plane to a body hanging vertically, whose mass is 20 grams. Determine the actual acceleration, and the tension of the string in dynes. ($g = 980$ cm. per sec. per sec. Give work in full.)

2. (*a*) Explain emission and absorption spectra. (*b*) What is the cause of the dark lines (Fraunhofer's lines) of the solar spectrum?

3. Give the laws governing the transverse vibration of strings.

4. (*a*) State the effect of fusion on the volume of solids, and give examples. (*b*) What is the effect of pressure on the fusing point?

5. Describe and explain Wheatstone's bridge, giving diagram.

Chemistry, Inorganic and Organic.

1. State and illustrate the law of periodicity in the properties of elements.

2. How may the molecular weight of a chemical compound that is volatile without decomposition be determined? Explain fully the fundamental principles involved.

3. Describe the preparation and properties of arsenic. Give a test for arsenic.

4. Give the formula of alcohol, aldehyde, and acetic acid. What is the relation between these substances?

5. Write the formula of olefiant gas. Of what is olefiant gas a principal constituent?

Mathematics.

1. Factor $9 - x^2 - 4y^2 + 12xy$ and $64x^2 - 12xy - 45y^2$.

2. Given $\left\{\begin{array}{l} (x+y)^2 - z^2 = 117 \\ x^2 - (y+z)^2 = 13 \\ x + y - z = 9 \end{array}\right\}$, find the values of x and y.

3. Find the equation whose roots are, 0, 3, $-1 \pm \sqrt{5}$, and a.

4. Prove that the figure formed by connecting the middle points of a trapezium, taken in order, is a parallelogram, and that its area is one-half the area of trapezium.

5. Determine the number of regular polyhedrons possible.

Technics.

Answer at least five of the following questions:

1. Describe the manufacture of kerosene from crude oil.

2. Describe the manufacture of matches.

3. Describe a time lock.

4. (*a*) What are meant by "eccentricity" and "angle of advance" as applied to valve gearing? (*b*) Describe an automatic steam governor which acts by varying these quantities.

5. (*a*) Describe, and illustrate by diagrams, the windings in a series, a shunt, and a compound-wound dynamo. (*b*) State why the last form of winding is better adapted to yield a constant potential under varying loads than the first two forms.

6. Describe the manufacture of water gas. How are the by-products separated?

7. Describe the manufacture and galvanizing of iron wire.

8. Describe the safety devices commonly employed on passenger elevators.

9. Describe the manufacture of bicycle tubing.

10. Describe the construction of a polyphase motor, and explain its mode of operation.

Mechanical Drawings.

For this subject the competitor will be given photolithographic copies of drawings of some kind, or portions of machinery, and will be required to describe the construction and operation of the machine represented, naming the different views shown, and the mechanical powers that appear. (The competitor will be instructed as to the name or use of the machine.)

French or German.

The examination is identical in scope for each language, and provides one general and two technical exercises in each language, each of the exercises containing about 125 words. The competitor must select and make translations of any two of the exercises in the language chosen without the aid of a dictionary.

ASSISTANT, NAUTICAL ALMANAC OFFICE, NAVY DEPARTMENT.

Age limit, 20 years or over; application forms 304 and 375; time allowed, two days of seven hours each. As to applying for this examination see page 4.

SUBJECTS.	Weights.
1. Pure mathematics	50
2. Practical computations	40
3. Spherical astronomy	10
Total	100

The following questions, which have been used, indicate the general character of the subjects:

MATHEMATICS.

1. Solve the following:

(a) $x^2 - 5\sqrt{2x^2 - 3x - 4} - x = \frac{x - 25}{2}$;

(b) $\sqrt{x - \frac{1}{x}} - \sqrt{1 - \frac{1}{x}} = \frac{x - 1}{\sqrt{x}}$.

2. Find the sum of (a) $\frac{1}{2} - \frac{1}{4} + \frac{1}{8} - \frac{1}{16} + \ldots$ to infinity; (b) If the middle term of $(1 + x)^{2n}$ is the same as the $(n + 1)$th term of $\frac{1}{\sqrt{1 - ax}}$, determine a.

3. (a) Prove the binomial theorem for positive integral exponents; (b) Expand $\frac{1}{\sqrt[7]{(a^2 - bx)^2}}$ to 5 terms.

4. Prove that a truncated triangular prism is equivalent to the sum of three pyramids whose common base is that of the prism and whose vertices are the 3 vertices of the inclined section.

5. Deduce the formulæ for the sine and cosine of half of any angle of a plane triangle in terms of the sides.

6. Find the equations of the tangent and normal to the ellipse $\frac{x^2}{25} + \frac{y^2}{16} = 1$ at point whose abscissa is 4 and ordinate positive. Find also the length of subnormal.

7. (*a*) Given $y = (\log \sin x)^{\cos e}$, find dy; (*b*) Show the geometrical signification of the first differential coefficient of the equation to a curve.

8. Expand $\tan^{-1}x$ in ascending powers of x and determine the value of π to 5 places of decimals.

9. (*a*) State Napier's Analysis and Gauss's Equations; (*b*) Find the intercept of $y + 4x = 2$ between $5x - y = 7$ and $y = 7x - 5$.

10. State De Moivre's Theorem and show how to determine thereby the roots of $x^4 + 4 = 0$.

(Generally 10 questions.)

Spherical Astronomy.

1. Define the following: Nadir, celestial sphere, azimuth, collimation, sidereal time, aberration, ecliptic.

2. Classify eclipses and state briefly the cause of each.

3. Explain the equation of time, and represent it by a curve.

4. Give the reasons why observers on the earth have been able to see more than one-half of the moon's surface.

5. Given $3x + 2y + 1$, $2x + 3y = -1$, and $x - 2y = -2$; find the most probable value of x and y.

(Generally 5 questions.)

Logarithmic and Astronomical Calculations.

1. In a plane triangle $a = 6238.7$, $b = 2347.5$, and $C = 110° \ 32'$, determine A, B, and c.

2. In a spherical triangle $a = 40° \ 5'.4$, $b = 118° \ 22'.1$, $A = 29° \ 42'.6$; determine c, B, and C.

3. Given $x = \alpha \sin(\beta + C\gamma)$, compute 6 values of x for $C = 1, 2, \ldots 6$, when $\alpha = -0.27163$, $\beta = 143° \ 47'.7$, $\gamma = 117° \ 53'.3$; add the 6 values and check by formula, sum $= \dfrac{\alpha \sin(\beta + \frac{7}{2}\gamma) \sin 3\gamma}{\sin \frac{1}{2}\gamma}$.

4. Given $\rho \cos \delta \cos \alpha = X + x$; $\rho \cos \delta \sin \alpha = Y + y$, and $\rho \sin \delta = Z + z$, where $\log x = 0.24332$, $\log y = 9.88888^n$, $\log z = 8.29369^n$, $X = 0.63451$, $Y = -0.23688$, and $Z = -0.00246$; determide ρ, δ, and α (ρ being positive).

5. Given $N = \dfrac{10^{1.0792}}{D^{0.708}}$. Compute values of N for D — 0.04 and 0.15

(Generally 10 questions.)

SUPERINTENDENT OF CONSTRUCTION, SUPERVISING ARCHITECT'S OFFICE, TREASURY DEPARTMENT.

Age limit, 20 years or over; application form, 1312; time allowed, two days of seven hours each. The first subject will be given on the first day and the remaining subjects on the second day. An applicant must have had at least five years of practical experience in building construction, either as a superintendent proper, contractor, architect, or engineer, and must establish this experience to the satisfaction of the Commission prior to being admitted to the examination. Subjects of examination and relative weights of subjects on a scale of 100: materials and building construction, involving extensive knowledge of all materials employed in first-class buildings and of details of construction, 40; mathematics, comprising arithmetic, accounts, and elements of plane geometry and mensuration, 10; building supervision, tests in the form of business communications which require adaptability, a knowledge of the qualifications necessary for this position and knowledge of the work gained by experience, 15; specifications, involving knowledge of the details of complete specifications for the various classes of work required in first-class buildings, 10; training and experience (see sec. 30 for time of filing application), 25. The duties of the position require the appointee's continuous residence in the city where the building under his superintendence is being constructed; but, as the necessities of the service require that superintendents of construction of public buildings shall serve in any part of the United States, they may be detailed from building to building as required.

The following questions and tests which have been used indicate the general character of the examination:

Materials and Construction.

1. What are the requisites of first-class building brick, of best quality lime, and of best quality building sand?

2. What are the characteristics of good cement; what tests are necessary to determine its quality, and in what respects do Rosendale and Portland differ?

3. (*a*) What is "dry rot" and how is it prevented in buildings? (*b*) What are the requirements of first-class yellow-pine lumber? (*c*) In what respects do cast iron, malleable iron, and steel differ?

4. (*a*) What is quarry water, what is its effect on stone, and how is it gotten rid of? (*b*) Compute the number of cubic feet of well-rammed concrete to be obtained from the following materials: Three bbls. (packed) Portland cement, 11 bbls. sand, 9 bbls. gravel, and 15 bbls. ordinary broken stone. (Show work in full.)

5. In foundations, what various means are adopted to increase the bearing capacity of a yielding soil?

6. (*a*) What precautions must be taken to insure good joints and bond in (1) brick masonry, (2) ashlar facing with brick backing? (*b*) Give a pen-and-ink sketch of section and plan of a fireplace, with hearth and trimmer arch, opening 2 ft. 6 in. high, 3 ft. wide, and 16 ft. deep.

7. What is "slow-burning construction"? Give a neat pen-and-ink sketch of the post-and-girder connections and of the floor construction of a building of this type.

8. Give pen-and-ink sketch of sections through head, sill, and jamb of a sliding-sash window frame; name the different parts, and specify the material for each part.

9. Give neat pen-and-ink sketch of sections through a door jamb, and through the stile of a veneered door; name the different parts in each case, the materials for each part, and describe or show plainly by sketches the method of construction.

10. Make a neat pen-and-ink sketch showing longitudinal section through string of an iron staircase with marble treads; also show a section of gallery casing in a fireproof building, the floor to be of marble.

Arithmetic and Mathematics.

1. Extract the square root of 492,868.586116.

2. A contractor agrees to complete a piece of work in 30 days, and puts 17 men to work on it, the working day being 8 hours. At the end of the 13th working day 5 men quit work, and he finds that only $\frac{1}{3}$ of the work has been done. How many extra men, provided the total force works hereafter 9 hours per day, will it be necessary for him to hire at once so that he may fulfill his contract?

Divide $5\frac{2}{5}$ by $\frac{9}{32}$, multiply the quotient by 3.5468, and from the product subtract $\frac{11}{16}$ of 13.76.

4. The depth of a building lot is one foot less than double its frontage. If a strip 1 yd. wide be taken off all around, the area is diminished 210 sq. ft. What is the area of the original lot in square feet?

5. The plan given shows excavation for house. General excavation is 6 ft. 9 in. deep and deep-area windows 4 ft. 8 in. deep. The ground is level. Find total excavation in cubic yards.

6. The area of a circle is 272 sq. ft. Find its radius and circumference in feet and inches.

7. The axes of an ellipse are 4 and 6 in., respectively. Show one method of constructing it graphically.

8. A beam of uniform cross-section 25 ft. long and weighing 50 lb. per ft. is placed on a rail. It has a load of 150 lb. at 2 ft. from one end and 400 lb. at 5 ft. from the other. If there is equilibrium, find position of supporting rail from each end of beam in feet and decimals of a foot.

9. Given two circles of different radii, one of which lies either wholly or in part outside of the other, show, geometrically, how to draw a straight line tangent to both circles.

10. From the given sketch calculate the strains on the jib and the chain of this crane. State whether tension or compression.

Building Supervision.

1. (*a*) State what mental and moral qualities a successful superintendent must possess. (*b*) State what technical qualifications he should possess.

2. (*a*) How would you check the stakes defining the lot on which a building is to be erected, under your superintendence, and how would you fix them for future reference? (*b*) What points would you attend to in the excavation for foundation?

3. (*a*) The foundation having been excavated to the depth specified, how would you test its bearing capacity? (*b*) If its capacity did not come up to requirements of specification, what would you do?

4. If the nature of the soil is such that wooden piles must be used and have been specified, state fully what you would do, as a superintendent, from the time of arrival of the piles on the ground until they are driven in conformity to contract requirements.

5. State what precautions you would take in order to obtain the best quality of work and best results in foundation footings (*a*) of concrete, (*b*) of brick, and (*c*) of stone.

6. In the superintendence of cut work, either in granite, sandstone, or limestone, what precautions would you take in order to obtain the specified standard (*a*) in material, (*b*) in the cutting and molding, and (*c*) in the setting of the stone?

7. If, in your opinion, the contractor is using material not up to specification, or the quality of the work done, through inefficiency of workmen or other cause, is not first-class; and, generally, when the work in any respect is not being conducted or performed accord-

ing to your interpretation of specification and contract, state, in detail, what course or courses you would pursue.

8. State what general considerations should govern a superintendent's course of action in all matters relating to his work.

Specifications.

(*a*) Give the general heads for a specification for a small brick office building with fireproof floors and roof. (*b*) Give rough draft of specification for the brickwork, woodwork and ironwork for the same.

DRAFTSMAN, TOPOGRAPHIC.

Age limit, 20 years or over; application form, 1312; time allowed, two days of six hours each. Subjects of examination and relative weights of subjects on a scale of 100: Drawing, a specimen of topographic drawing will be given for reproduction, in India ink, 35; Lettering, tests on short words and numbers in different styles of lettering, 35; Mathematics, comprising arithmetic, algebra to and including problems involving quadratics, plane and solid geometry, plane trigonometry, logarithms, mensuration and projections, 30.

The supply of eligibles for this position has not been equal to the demand.

Note.—Competitors who fail to attain an average rating of at least 70 in the subjects of drawing and lettering will not be eligible for appointment. Not more than four hours will be allowed on the second day for work on drawing and lettering. No submitted drawings will be accepted. Competitors who average 70 per cent. or over in the subjects of drawing and lettering may also have their names entered on the copyist topographic draftsman register, provided that they each file an application for copyist topographic draftsman in ample time for the examination.

DRAFTSMAN, COPYIST TOPOGRAPHIC.

Age limit, 20 years or over; application form, 1312; time allowed, two days of six and four hours, respectively. Subjects, examination and relative weights of subjects on a scale of 100; Drawing, a specimen of topographic drawing will be given for reproduction in India ink, 50; Lettering, tests of short words in different styles of lettering and numbers are given, 50. The tests in drawing and lettering are identical with those given in the topographic draftsman examination. Competitors who take both examinations will take these tests but once. No submitted drawings will be accepted.

The following questions and tests which have been used indicate the general character of the subjects of geographic projections, geography, and mathematics:

Geographic Projections.

State fully and clearly the principles of polyconic projection, and describe in detail the process of constructing, by this projection, a map of that part of the United States and Canada lying between 30° and 50° north latitude and 70° and 90° west longitude. The scale of the map is to be $\frac{1}{1\ 200\ 000}$.

Geography.

1. Name five States bordering on the Great Lakes and name an important river in each of the States required.

2. Name five States which border on the Missouri River, and name the capital of each State required.

3. In what State is each of the following-named located: Fremont Peak, Tulare Lake, Mount Mitchell, Schoodic Lakes, Mount Baker?

4. Name the most populous city in each of the following-mentioned States and the river or body of water on which each is situated: Connecticut, West Virginia, North Dakota, Washington, Arkansas.

5. Name two States which border on each of the following-mentioned rivers or bodies of water: Potomac River, Lake Champlain, Savannah River, Columbia River, Sabine River.

Mathematics.

1. Same as question 1 of the arithmetic of first grade, see Sec. 35.*

2. Divide $5\frac{2}{5}$ by $\frac{9}{32}$, multiply the quotient by 3.5468, and from the product subtract $\frac{11}{16}$ of 13.76.

* See Manual of Examinations, U. S. Civil Service Commission.

3. Three draftsmen, *A*, *B*, and *C*, are engaged upon a piece of work. *A* can do it alone in 7, *B* in 15, and *C* in 21 days. After the three men work together $1\frac{3}{5}$ days *B* stops work. How long will it take *A* and *C*, working together, to complete the work?

4. Extract the square root of 94,254.526081.

5. What size sheet of paper, in inches, would be required for a map covering one degree of latitude and longitude, on a scale of $\frac{1}{80000}$, to allow a margin $1\frac{1}{4}$ in. wide all around, outside the neat lines, if one minute of latitude is equal to 1,850 meters and one of longitude on the largest arc is equal to 1,356 meters?

6. Show how to draw a circle through three given points not on a straight line, and prove your construction.

7. Find the point on a given straight line, such that the sum of the distances from it to two given points not on this line may be the least possible.

8. Given $\frac{x-5}{4} - \frac{2x-y-1}{3} = \frac{2y-2}{5}$, and $\frac{2y+x-1}{9} = \frac{x+y}{4}$, find x and y.

9. Given $x^2y + xy^2 = 20$, and $\frac{1}{x} + \frac{1}{y} = \frac{5}{4}$, find x and y.

10. In a triangle *A B C*, the angles *A* and *B* and the side *a* are given. Write down the formulæ for finding *C*, *b*, and *c*, and express the logarithms of these in terms of those of *A*, *B*, and *a*.

No specimen questions in the fifth, sixth, and seventh subjects can be furnished.

DRAFTSMAN, ARCHITECTURAL, SUPERVISING ARCHITECT'S OFFICE.

Age limit, 20 years or over; application form, 1312; time allowed, two days of eight hours each. The first two subjects will be given on the first day and the third subject on the second day. Subjects of examination and relative weights of subjects on a scale of 100: Building materials and construction, involving extensive knowledge of all materials employed in first-class buildings, of details of construction, and of specification forms for such work, 25; free-hand drawing, ornament and projection, involving ability to make free-hand perspectives, large-scale free-hand drawings of styles of exterior and interior decoration and shadow casting, etc., 25; drawing and design, involving the drawing of plans, elevations, and details for modern first-class buildings to scale according to given specification, 30; training and experience, 20.

DRAFTSMAN, JUNIOR ARCHITECTURAL, SUPERVISING ARCHITECT'S OFFICE.

Age limit, 20 years or over; application form, 1312; time allowed, two days of seven hours each. The first two subjects will be given on the first day and the remaining subject on the second day. Subjects of examination and relative weights of subjects on a scale of 100: Materials and building construction, elementary questions in materials and details of construction, 25; free-hand drawing and projection, elementary questions involving ability to draw perspective views, plans, and elevations of regular solids, examples of decoration, cast shadows, etc., 25; drawing, involving ability to draw neatly and correctly to scale, sketch drawings submitted, 40; training and experience, 10.

The following questions and tests which have been used will indicate the general character of the above-named examinations:

(a) Junior architectural draftsman.

Elementary Mathematics.

1. This question comprises a test in adding figures crosswise and lengthwise. There are usually three columns of about twelve numbers each to be added.

2. Multiply 382.58 by $\frac{3}{7}$ of 27.342, and divide the product by $\frac{1}{2}$ of 34.78. (Work by decimals.)

3. Extract the square root of 492,868.586116.

4. Given a straight line of definite length, show how to divide it graphically into four parts proportional in length to the numbers 1, 2, 3, and 5.

5. Describe a circle through any three given points not in a straight line, and prove your construction.

Knowledge of Materials and Construction.

1. What are the characteristics of first-class building brick, best quality lime and building sand?

2. Name four different bonds employed in brickwork. Make neat pen-and-ink sketch plans and elevations of each.

3. Explain or show by sketch the best method of framing studs and joists on sills, and make, also, a neat sketch section through the sill and the stone foundation of a frame house.

4. Make a sketch section and elevation in ink, showing the construction of an ordinary panel door; name all the parts. Draw a sketch about one-sixth full size, showing section through a veneered door.

5. Show by a sketch the method of framing a floor around a chimney in an outside brick wall, and name the different parts of the framing.

Orthographic Projection and Free-Hand Drawing.

A right regular triangular prism, whose height is $2\frac{1}{2}$ in., and the edge of whose ends is $1\frac{1}{2}$ in., stands on one end as a base, with two edges of base equally inclined to the vertical plane. The center of the base is $1\frac{1}{4}$ in. from the vertical plane.

1. Draw plan and elevation, and show true form of section made by a cutting plane at right angles to the vertical plane, at 45° to the horizontal plane, and bisecting the axis of the prism.

2. Draw the development of the lower part of the prism.

3. Make free-hand drawing in pencil of sketch of ornament furnished, enlarging to twice the size there shown.

4. Make free-hand drawing in ink of the study for house, enlarging to twice the size there shown.

Architectural Drawing.

1. Name the five orders of architecture and the principal parts into which an order is divided.

2. Draw, in pencil, a Roman Doric cap, using 2 in. as a module.

3. The plan given on sheet *5a* is to $\frac{1}{32}$-in. scale. Enlarge to $\frac{1}{16}$-in. scale and finish in pencil.

4. Make a copy of the elevation given on the same sheet, in pencil. Use the same scale as in copy. Finish one bay complete.

5. Make a tracing, in ink, of your drawing furnished in answer to 4.

NOTE.—The drawing given in connection with questions 3, 4, and 5 will be a simple plan and elevation of a small public building.

(b) Architectural draftsman.

KNOWLEDGE OF MATERIALS AND CONSTRUCTION.

1. Give, to about 1-in. scale, a sketch plan and section of a fire-place with hearth and trimmer arch, the opening to be 2 ft. 6 in. high, 3 ft. wide, and 16 in. deep.

2. Give two sketch plans of a brick pier between two windows, faced with ashlar, showing the bond of the ashlar and the anchors and cramps required to bond the work.

3. What is "slow-burning construction"? Give a pen-and-ink sketch of the post and girder connections and of the floor construction in a building of this type.

4. Of what materials are (1) concrete, (2) lime mortar, (3) cement mortar, (4) first coat of plaster composed; in what way is each used, and in what proportions are the materials mixed in each case?

5. What are the characteristics of good common brick and good building sand, and what tests would you employ to ascertain their quality? In what respects do Rosendale and Portland cements differ?

6. Give sections through the head, sill, and jamb of a sliding-sash window frame, name the different parts, and specify the material of which each part should be made.

7. What are the characteristics of first-class yellow-pine lumber? Define wet-rot and dry-rot, and state how each is prevented.

8. How would you specify a joint to be made between (*a*) cast-iron pipes and (*b*) between a cast-iron pipe and a lead one? What minimum fall would you allow in a sewer from house to street?

9. Show, by a neat pen-and-ink sketch, the proper method of arranging a ventilated running trap outside the wall of a building and on the line of pipe connecting the sewer.

10. Make a neat pen-and-ink sketch showing longitudinal section through string of an iron staircase with marble treads; also show a

section of gallery casing in a fireproof building, the floor to be of marble.

The drawings required to be made under instructions given above represent elevation and first-floor plan of a federal building. Stone facing. Fireproof construction.

1. Give the headings of the principal subjects to be covered in a specification for such a building.

2. Give a short outline draft of a specification for the cut-stone work.

3. A short outline draft for the brickwork.

4. A short outline draft for the carpenter work.

5. A short outline draft for the painting and glazing.

Drawing and Design.

1. Name and describe in outline the Greek and Roman orders, mentioning the principal points in which they differ.

2. Draw, in pencil, with a module of ½ in., the Corinthian order, and give the proper technical name for each of its parts and members.

3. Lay out, in pencil, to ⅛-in. scale, the sketch plan shown on sheet 4*a*, and figure your drawing fully.

4. Lay out the elevation, in pencil, to the same scale, finish one-half of your drawing, and figure the openings.

5. Make a tracing in ink, on linen, of your drawings in answer to questions 3 and 4, and letter the tracing neatly.

For questions 3, 4, and 5 a rough sketch plan and elevation of a public building was given.

Free-hand Drawing and Orthographic Projection.

Give finished pencil sketches of two of the following-named styles of ornament, and indicate your selection:

1. Greek or Roman. (Select one.)

2. Gothic or Renaissance. (Select one.)

3. A right, regular octagonal prism, whose height is 3 in. and the edge of whose ends is 1 in., stands on an edge of one end on the horizontal plane, with its axis parallel to the vertical plane, at 60° to the horizontal plane and 1½ in. from the latter. The edge on a

horizontal plane is inclined at 60° to the vertical plane. Draw plan and elevation.

4. Show true form of section made by a horizontal cutting plane which bisects the axis, and develop the lower part of the prism.

5. An octagonal column, 3 in. high, and the diagonals of whose base are $2\frac{1}{2}$ in., stands vertical and has a plinth 4 in. square and 1 in. thick lying flat on top. One face of the plinth and one of the column show full in elevation. Show exact form of shadow cast by plinth on column by a direct light falling at 45°, as is usual in drawings.

(c) **Structural-steel draftsman.**

HIGHER MATHEMATICS AND MECHANICS.

6. Assuming the formula for determining the solidity of a cone as proved, show that the volumes of two similar cones of revolution are to each other as the cubes of their heights.

7. Given two adjacent sides, a and b, of a triangle, and also the included angle C, show how to solve the triangle.

8. Find the points where the straight line $y = \frac{3}{4}x + a$ cuts the parabola $y^2 = 4ax$, and the length of the part intercepted.

9. Given $x^3 + y^3 - 3axy = c$; find $\frac{dy}{dx}$.

10. Integrate $\frac{3x - 5}{x^2 - 6x + 8}dx$.

11. A 20-in. I-beam, 70 lb. per ft., has an 8 by $\frac{1}{2}$-in. plate riveted on the bottom flange. Find the position of the center of gravity, the moment of inertia, and the radius of gyration of the combined section. (Moment of inertia for 20-in. I-beam 70 lb. per ft. = 1 220.)

12. A steel plate girder 30 ft. long and 3 ft. deep carries a center load of 30 000 lb. and a distributed load of 2 000 lb. per ft. If the maximum strain on extreme fibers is 15 000 lb. what is the moment of inertia of the section?

13. A beam 25 ft. long has a load of 10 000 lb. at 5 ft. from one end and a distributed load of 1 000 lb. per foot. What is the maximum bending moment, and where does it occur?

14. State the theorem of (a) the parallelogram of forces; (b) the parallelopiped of forces, and (c) the resultant of any number of parallel forces.

15. Three forces, A, B, and C, are in equilibrium. Having given the magnitude and direction of A, the magnitude of B, and the direction of C, determine the magnitude of C and the direction of B. When is the solution impossible?

Knowledge of Materials, Drawing and Design.

(Use of slide-rule is permitted in computations.)

1. Figure the strains on the members of the truss shown below. Assume wind pressure as 40 lb. per sq. ft. horizontal; snow, roof, and covering as 40 lb. per horizontal sq. ft. Truss is fixed at A and rests on steel built column 20 ft. high; free at B, resting on rollers on brick wall. Distance between trusses is 10 ft. To prevent bending of column a knee brace is to be provided. Distance from foot of column to knee brace is 12 ft. Show all your calculations. (A Fink roof truss, 100 ft. span and 25 ft. rise, was given.)

2. Show, in pencil, details at A and B, and of foundation of column, so that maximum pressure on subsoil may not exceed 1 000 lb. per sq. ft. Find, also, strain in knee brace and bending moment on column.

3. (*a*) Describe briefly the process to which ore is subjected before it is suitable for structural cast-iron work. (*b*) Name and describe, in detail, one method of making steel.

A. A floor space, 25 by 40 ft. clear, is to be covered with a steel beam and girder floor without columns. The total floor load, including weight of floor, is 400 lb. per sq. ft. Allowing maximum strain on fibers of 15 000 lb. per sq. in., show by a neat pen-and-ink figured sketch the most economical and suitable arrangement. Add written notes when necessary. The moment of inertia of 10-in. I-beam 25 lb. per ft. is equal to 122.5; 10-in. I-beam 33 lb. per ft. is equal to 161.3; 12-in. I-beam 32 lb. per ft. is equal to 222.3; 12-in. I-beam 40 lb. per ft. is equal to 281.3; 15-in. I-beam 41 lb. per ft. is equal to 424.1; 15-in. I-beam 50 lb. per ft. is equal to 529.7; 15-in. I-beam 60 lb. per ft. is equal to 644; 15-in. I-beam 80 lb. per ft. is equal to 785.

5. A plate girder 27 ft. long and 3 ft. deep carries a load of 3 000 lb. per ft. and a concentrated load of 50 000 lb. at 6 ft. from each end. Proportion the girder to sustain this total load, allowing maximum flange strain of 15 000 lb. per sq. in., and shear in web and rivets of 8 000 lb. Show all your calculations.

6. Make detail drawings, in pencil, of the girder to $\frac{3}{4}$-in. scale. Figure all dimensions and rivet spacing.

7. A column carries, at first floor level, four beams. The beams are arranged and transmit to the column the loads as shown on the

sketch below. Length of column is 13 ft. from base to top of beam at first floor and 25 ft. from top of beam at first floor to top of beam at second floor. The column rests on a concrete base and is to be built of plates and angles. Design the column and all connections. Assume strain on column as 10 000 lb. per sq. in., shearing value $\frac{7}{8}$-in. rivets as 6 000 lb., and bearing value of $\frac{7}{8}$-in. rivets as 15 000 lb. per lin. in. of bearing. Allow pressure on concrete base of 8 tons per sq. ft. Show all your calculations.

8. Make a drawing, in pencil, of the column, showing all connections and base.

NOTE.—For question 7 the column carries, at first-floor level, four beams at right angles, in pairs, and unequally loaded; at second-floor level three beams, unequally loaded and at 120° to each other, are carried.

(d) **Heating and ventilating draftsman.**—First subject same as in junior architectural draftsman.

PRACTICAL KNOWLEDGE OF HEATING AND VENTILATION.

1. Name the various means employed for warming buildings and briefly describe the principal systems.

2. Describe the construction of the usual style of direct radiators used for direct hot-water heating.

3. State the difference between direct steam radiators and those used for direct hot-water heating.

4. Where should automatic air-valve be located on a direct steam radiator, and also on an indirect steam radiator?

5. (*a*) How should flow and return pipes of a low pressure steam heating apparatus be graded? (*b*) How should similar pipes of a low temperature hot-water heating apparatus be graded? (*c*) How is air expelled from a hot-water heating system?

6. Explain the use of eccentric fittings in the pipe system of a steam-heating apparatus.

7. What is the relative position of outlets of a 6 by 4 by 2-in. eccentric "T" placed in the main flow pipe of (*a*) a low-pressure steam-heating apparatus, and (*b*) a low-temperature hot-water-heating apparatus?

8. State how globe-valves should be placed on horizontal steam-flow pipes.

9. Explain the use and operation of automatic air-valves on steam radiators.

10. To warm and ventilate a building it is necessary to introduce 570 000 cu. ft. of fresh air per hour, which amount of air is to be heated from plus 20° to 110° Fahr. by indirect radiation. The indirect radiation to be used will emit 470 h. u. per sq. ft. per hour. How many square feet of indirect radiation will be required.

Drawing and Design.

1. (*a*) Illustrate by free-hand sketch how drip pipe from a vertical steam-flow riser is run and connected to the corresponding return riser, both flow and return risers being valved. (*b*) Make a free-hand section of a 2-in. globe valve. Sketch to be made approximately full size and clearly show construction of valve.

2. Draw three-fourths-inch scale section of an indirect radiator of a low-pressure steam-heating apparatus, located in a brick chamber in the basement of a building. The indirect radiator to be located and shown in outline only; but connections to same, including valves, cold-air supply duct with damper, hot-air exit flue, construction of ceiling of chamber, manholes, etc., must all be fully illustrated. Drawing to be clear and distinct and to be made in pencil only.

3. Make finished ink drawing, side and end elevations and section through trench and part section of wrought-iron blow-off tank and pipe connections to same, all as illustrated by sketch furnished. End elevation to be taken from line *a b*, scale to be $\frac{3}{4}$ in. to 1 ft.

(e) **Electrical engineer and draftsman.**—First subject same as in junior architectural draftsman. Specimen questions in second and third subjects can not be furnished at this time.

CIVIL ENGINEER, DEPARTMENTAL SERVICE.

Age limit, 20 years or over; application form, 1312; time allowed, two days of six and three hours, respectively. The first two subjects will be given on the first day and the third subject on the second day. Subjects of examination and relative weights of subjects on a scale of 100: Pure and applied mathematics, elementary problems in mensuration, solution of plane triangles, and theoretical and applied mechanics, involving a fair knowledge of pure mathematics to and including calculus, 20; use and construction of instruments, and surveying, comprising transit, including stadia work, level, plane table, rod, chain, tape, current meters, etc., surveying, leveling, and other field work required in civil engineering and not covered in subject 1, 30; design and construction, involving elementary knowledge of designing and constructing highways, railroads, dams, retaining walls, foundation work, trusses, etc., 25; training and experience (see Sec. 30 for time of filing application), 25.

NOTE.—No applicant who has not had at least five years' good experience in civil engineering work will be admitted to the examination. Graduation in civil engineering from any reputable technical school will be considered equivalent to three and one-half years of this period. Students of civil engineering about to graduate or just graduated, and others who have filled minor positions such as chainmen, rodmen, levelmen, etc., and who have not received a suitable technical training, are advised to apply for subordinate positions under the Engineer Department in their locality.

CIVIL ENGINEER, PHILIPPINE SERVICE.

Age limit, 18 to 40 years; application forms, 2, including medical certificate, and 375. For description of examination see Sec. 65. For further requirements see Sec. 35.

Appointments will be made at salaries ranging from $1 400 to $1 800, depending upon the rating received in the examination and the amount of practical experience gained subsequent to graduation. Under the provisions of Section 21 of the Philippine civil service act, the higher positions are filled by promotion, without examination, of persons in the classified service who are, in the judgment of the appointing power, available and possess the qualifications required. There are at present about eighty civil engineer positions in the Philippine service, ranging from $1 200 to $5 400 per annum. Of this number nine receive $3 000 per annum or more.

CIVIL ENGINEER AND DRAFTSMAN.

Age limit, 20 years or over; application form, 1312; time allowed, two days of six and seven hours, respectively. The test in civil engineering will occupy the two days and will be identical with the civil engineer examination, so that those who intend to qualify as draftsmen will take this test but once. The test in drawing will be given on completion of the civil engineer examination. No submitted drawings will be accepted.

All eligibles in the civil engineering subjects who receive a rating of not less than 70 per cent. on the drawing test will be eligible as civil engineers and draftsmen. Those who fail to receive a grade of 70 per cent. on the drawing will be eligible as civil engineers only. In determining the average percentage, the subjects of the civil engineer examination will be given a weight of 60 and the subject of drawing 40.

CIVIL ENGINEER AND SUPERINTENDENT OF CONSTRUCTION.

Age limit, 20 years or over; application form, 1312; time allowed, two days of seven hours each. First day, subject 1, and subject 2 begun; second day, subject 2 finished and subject 3. Subjects of

examination and relative weights of subjects on a scale of 100: Mathematics, elementary problems in mensuration, solution of plane triangles, and theoretical and applied mechanics, involving a fair knowledge of pure mathematics up to and including calculus, 15; theory and practice of surveying and use and care of instruments, comprising transit, including stadia work, level, plane table, rods, chain, tape, etc., surveying, leveling, and other field work required in civil engineering, 30; building construction, specifications, etc., involving good knowledge of all materials employed in first-class buildings and of details of construction and of specifications, 30; training and experience.

IRRIGATION ENGINEER, GEOLOGICAL SURVEY.

Age limit, 20 years or over; application form, 1312; time allowed, two days of seven consecutive hours each. The medical certificate in application form 1312 will be required, and those who are not physically sound and able to perform field duty under trying conditions will not be admitted to the examination. The first three subjects are given on the first day, the remaining subjects on the second day.

Subjects of examination and relative weights of subjects on a scale of 100: Mathematics, pure and applied; algebra, including problems involving quadratics; plane and solid geometry; plane trigonometry, and elementary problems in applied mechanics, 10; topographic and construction sketching and lettering, competitor must show ability to make intelligible drawings of engineering and topographic features, 10; general surveying, topographic, hydrographic, and United States, theory and practice as covered in Manual of General Land Office and first-class surveying text-books, 15; engineering and hydrographic construction, questions to illustrate the general practice used on works both on land and in water, including strength of materials and specifications for the same, 20; discussion of engineering and hydrographic data, the preparation of brief papers on various practical hydrographic problems connected with irrigation, power, water supply, sanitary engineering, etc., 15; training and experience.

From the eligible list obtained from this examination vacancies occurring in the various grades of the Engineering and Hydrographic Corps will be filled, including positions of assistant engineer and of hydrographer. The salaries range from $1 000 to $2 000 and upward. Subsistence and traveling expenses are paid when on field duty. The salaries will depend upon the experience of the competitors.

ENGINEER INSPECTOR.

Technical.

1. State all the ways in which you would examine the notes of a closed survey to test its accuracy, both as to angular and linear measurements.

2. What is the fundamental requirement in all foundations to insure equality of settlement in all parts?

3. (*a*) What points have to be considered in determining the bearing power of piles in any given case? (*b*) State the circumstances, if any, where other than vertical force must be considered.

4. Aside from construction and the wearing surface of streets and roads, what important considerations govern the design and execution of such works to insure permanency and freedom from unevenness in wear?

5. Suppose you were ordered to make hydrographic survey for several piers on the North River side of the city; state clearly how you would lay out the work, what you would do and how you would do it. Illustrate by sketches, if you so desire.

6. (*a*) Describe the method of making a survey of a reservoir site. (*b*) State clearly the method of computing the cubical contents of such reservoir to the flow line.

7. Bearing and length of tangents given, (*a*) show how you would lay out a simple railroad curve by use of transit instrument. (*b*) Show at least one way of doing the same by use of chain or tape only.

8. A culvert to care for certain surface drainage is to be built under a road; show how you would determine the necessary site.

9. Describe the proper construction of a weir for measuring the flow of water, and the precautions to be observed in its use.

10. Suppose the upper surface of a dam to be vertical; (*a*) state at what depth the center of pressure of the water could be located. (*b*) State what the pressure per foot of length of the dam would be, taking the depth as (*a*).

11. What other ways are there for measuring the flow of water than by the use of weirs?

12. (*a*) Describe the action of the internal forces in a beam under transverse load. (*b*) Give the relation between a central load (P) and the unit strain (S) on a beam of length (l), depth (b) and width (w).

13. Describe what is meant by the term "shear" in computing the strength of bridges and how it is determined.

14. In riveted work the bearing value and the shearing value have both to be considered. (*a*) Describe the cases in which each may be the governing element in computing the strength of the work. (*b*) About what values would you take for each?

15. Why is it desirable that the center of pressure in masonry (as in the keystone of an arch) or in a foundation (as that of a retaining wall) should not lie outside of the middle third of the joint? Is such condition necessarily fatal to the work?

Mathematics.

(Note: Show every figure.)

1. Compute the number of square feet of pavement in a street 50 ft. between curbs and on a curve of 75° with a radius of center line of 500 ft.

2. A rectangular field is 60 ft. long and 40 ft. wide, and is surrounded by a road of uniform width, having an area equal to that of the field; what is the width of the road?

3. The population of the upper and lower parts of a town were equal, and after the former had fallen 20 per cent. and the latter risen 15 per cent., the total number of inhabitants was 39,390. What was the population of each part at first?

4. Extract the square root of 100.0200013.

5. Subtract the sum $a - x - a - x - (2x - 4)$ and $a - x - a\ x - (a - 2x)$ from $2a - x$.

Reports.

Write a report on a new street of considerable length in one of the annexed districts. Begin with the original survey, followed by the location, adoption of grades (with reasons for all conclusions), a schedule of quantity to be used in letting of the work, and inspection of grading, and of paving with granite block pavement.

CIVIL ENGINEER AND SUPERINTENDENT OF CONSTRUCTION.

1. A road is to be built 25 ft. wide. State how to calculate cut and fill, and how to establish grade line embankment 1½ to 1 ft.

2. Two guy ropes 15 ft. in plan. Figure out all stresses on various parts, jib, two guy ropes and chain. Name nature of stresses. Graphic method preferred.

3. If you have the use of a transit for field work and same is in perfect condition, state in detail how you would proceed to keep it in its parts and as a whole in that condition.

4. (*a*) State clearly the principle on which stadia measurements are based. (*b*) Explain and illustrate by large sketch the reading of the vernier. (*c*) Describe in detail the construction of a plane table.

5. If a line is to be run and chained across a stream with high shore and chaining is impossible, state in detail how to obtain the distance, the line crossing the stream at an agle of 65 degrees.

6. If a line of levels contains an error, state how to correct it, if corrections can be made at all.

7. State three different methods of surveying and discuss their respective methods.

8. When is it necessary to use piles for foundations? What is sometimes used instead of piles? Do pile foundations give entirely satisfactory results? How is the bearing capacity of piles computed?

9. Show by neat pen-and-ink sketch two different sections through ceiling and roof of a first-class fire-proof building.

10. Show three courses of bond, English, Flemish and American, on corner of 2½ ft. brick wall.

11. Show by sketch how a sewer-pipe connecting house with main sewer is trapped and ventilated.

12. Show base and elevation of a Z-bar column.

13. Write specification for concrete work.

14. Show by neat pen-and-ink sketch how pressed brick are bonded into rough brickwork.

15. Show by sketch a section about full size of a bar of copper skylight.

16. Show connections of three different sizes of I-beams.

17. Test in drawing and lettering.

Knowledge of Materials and Construction.

1. Of what materials are concrete, lime mortar, and first coat of plaster composed, in what way is each used, and in what proportions are they mixed?

2. What are the characteristics of good common brick, and good building sand, and what tests would you employ to ascertain their quality?

3. (*a*) In what respects do Rosendale and Portland cements differ? (*b*) What are the characteristics of first-class pine lumber?

4. Define and illustrate the following terms: (*a*) Needles; (*b*) Grout; (*c*) Fire Stops; (*d*) Templets; (*e*) Beds and builds; (*f*) Chases; (*g*) Bush hammered; (*h*) Staggered; (*i*) Crandalled; (*j*) Briquettes.

5. Give a plan and elevation of the floor framing around a chimney in an outside brick wall, and name the different parts.

6. Describe two different ways of securing ashlar facing to backing.

7. Give a section through a door jamb and through the style of veneered door. Name the different parts and materials for each.

8. (*a*) How would you specify joints to be made (1) between cast-iron pipes and (2) between a lead pipe and an iron one? (*b*) What is the least fall per foot that you would specify for a sewer from house to house.

9. Give sections through the head, sill and jamb of a sliding sash window-frame, in a brick wall, name the different parts, and specify the materials for each part.

10. Name four different bonds employed in brickwork. Make neat pen-and-ink sketch, plans and elevations of each.

Specifications.

For this subject the competitor will be given four drawings of the elevations and plans of a federal building and will be required to write a preliminary block specification, sufficiently detailed to enable a contractor to make a preliminary estimate.

Computing Quantities.

1. From the elevations and plans of the federal building given under the subject "specifications," take out the quantities of the brickwork.

2. From the same drawings, take out the quantities of the stonework.

3. Calculate the quantity of lumber (board measure) in the frame of the sides, floor, and roof of a framed structure of the following dimensions: 28 by 20 ft.; 12 ft. from top of sill plate to under side of cap plate; roof, $\frac{1}{3}$ pitch and placed longitudinally of building; sill, 4 by 8 in.; floor joists, 3 by 12 in., spaced 16 in. on centers; vertical studs, 3 by 4 in., spaced 16 in. on centers; corner studs, 4 by 4 in.; cap plates, 2 by 4 in.; rafters, 2 by 6 in., 16 in. on centers; ridge piece, 2 by 8 in.

4. (*a*) Calculate the weight, in pounds, of a C. I. column of the following dimensions: Length of shaft, 16 ft.; outside diameter, 15 in.; thickness of metal in shaft, $1\frac{1}{4}$ in. At each end is a circular flange 1 in. thick and projecting 3 in. beyond outside diameter of column. There are four stiffening ribs at each flange 1 in. thick and 3 in. deep. (*b*) Calculate the weight, in pounds, of a steel girder 30 ft. long; total depth at center, 3 ft. $4\frac{1}{2}$ in.; flanges, each 15 by 1 in., with additional plate, 15 ft. by 15 in. by 1 in.; web, $\frac{1}{2}$ in.; angle irons, $4\frac{1}{2}$ by $4\frac{1}{2}$ by $\frac{5}{8}$ in.; rivets, $\frac{3}{4}$ in., and 3-in. pitch throughout. Omit joint covers in estimation.

For questions 1 and 2, two plans and elevations of a small post-office building will be given.

EXAMINATION FOR ASSISTANT CIVIL ENGINEERS, PANAMA CANAL, JAN. 30 AND 31, 1905.

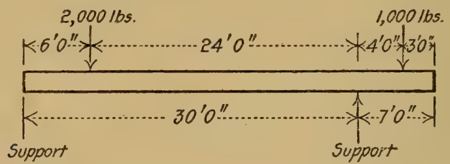
Relative weights:

Mathematics	20
Instruments	10
Surveying	10
Design and construction	20
Training and experience	40
	100

Two days of 7 consecutive hours each. First day, Mathematics and Instruments; second day, Surveying, Design and Construction.

MATHEMATICS.—Answer 3 and only 3 of the following:

1. Given the beam in sketch under a distributed load of 150 lb. per ft., with dead load of 30 lb. per ft. (linear) and carrying two concentrated loads as indicated:



(*a*) Construct shear diagram.

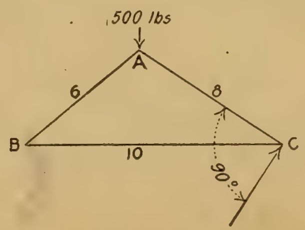
(*b*) Find point of maximum moment and amount of same.

(*c*) Assuming width of 6 in., section rectangular, and maximum allowable fiber stress of 800 lb. per sq. in., what should be the depth of beam?

(*d*) What would be the maximum horizontal shear? (Answer any three parts of this question.)

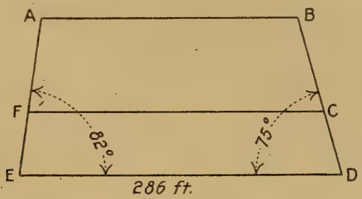
2. (*a*) A ladder 30 ft. long leans against a wall. The ladder weighs 50 lb. A man weighing 150 lb. and carrying 75 lb. weight is $\frac{1}{3}$ way up the ladder. Find reactions of ladder when (1st) it is hinged at top and (2) when it leans against the wall and friction with wall is zero. (Height of ladder top not given by candidate—overlooked probably.)

(*b*) In the pin-connected truss, sketched, find the amount of reaction at "*C*," amount and direction at "*B*" for equilibrium and find stress in each member.



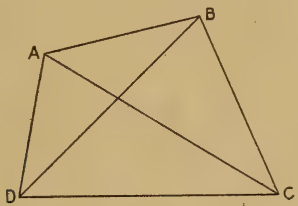
3. In the figure given $B\ D = \ \ 42$ ft.
$E\ D = 286$ "
$\angle D = 75°$
$\angle E = 82°$

Find length of frontages $B\ C$, $C\ D$, $E\ F$, and $F\ A$ to hundredths of a foot when area $A\ B\ C\ F$ is twice as large as area $C\ D\ E\ F$. Four-place logs. were supplied.



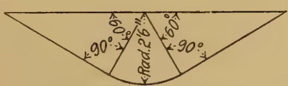
4. Given (see sketch) $D\ C = 1\,200$ ft. and azimuth of $D\ C =$ 188° 40′; az. of $D\ A =$ 97° 16′; az. of $D\ B =$ 130° 04′; az. $A\ C =$ 30° 23′; az. $B\ C =$ 76° 10′; find the length and azimuth of $A\ B$.

(Origin and rotation of azimuth not stated; evidently to be determined from sketch.)



5. The sketched figure representing a cross-section of a channel.

(*a*) Find discharge when running full if $C = 120$ (in formula) and slope is 3 ft. per mile.



(*b*) Find size of rectangular section for equivalent discharge if height is $\frac{1}{3}$ of base (running full).

(*c*) If a canal lock gate has 12 ft. of water on one side and 4.2 ft. on the other, what is the pressure on the gate (effective); where is the center of pressure, and what would be the initial velocity on raising the gate 6 inches?

INSTRUMENTS.—Answer three only.

1. A transit telescope is said to be achromatic, have no aberration, must have a flat field (and various other terms). Define each term.

2. Tell how you would care for an instrument to keep it in good order.

3. How would you use a transit to correct for instrumental lack of adjustment in the following cases:

(*a*) Prolonging a line.
(*b*) Measuring horizontal and vertical angles.

4. Given the formula for stadia measurement, $K\ s + d$, show how it is derived and how applied.

5. Draw with pen and ink a longitudinal sketch of a telescope, showing the lenses and other parts; and larger scale sketches to show the relative positions of leases and the shapes of same.

SURVEYING.—Answer three only.

1. How would you proceed to establish a base line in a tract of land 5 miles by $1\frac{1}{2}$ miles, broken by woods, ponds, streams, etc., to a correctness of $\frac{1}{50\ 000}$?

2. Having completed that work, how would you fill in your intermediate details? Using a transit reading to 20″, what degree of accuracy would you seek to obtain?

3. Describe how you would set about to obtain 2-ft. contours to plot to a scale of $\frac{1}{1200}$.

4. If the above is not according to your idea of procedure, describe in detail what you would do to obtain the necessary information.

DESIGN AND CONSTRUCTION.

1. Write specifications for concrete under water or on a wet subsoil, and give the tests required for each kind of material. This is to test the writer's knowledge of specification writing.

2. Describe what, in your opinion, is the best kind of street pavement. Draw sketches to show the pavement, sidewalks, sewers, drains, water and gas-pipes, etc.

3. A dam is to be built across a valley and the water level is to be 30 ft. above the thread of the valley. The soil consists of 6 ft. of

sandy clay over an indefinite depth of stiff gravelly clay. Make a sketch of an earth or masonry dam you would build to impound the water.

4. How would you drive piles in—
(*a*) Shifty, sandy soil?
(*b*) Gravelly soil?
(*c*) Stiff clay?

What precautions would you take? What length of pile would you use? How would you determine the bearing value of a pile in each case?

5. To design a wooden truss to carry a given load over a given span.

EXAMINATIONS FOR ASSISTANT CIVIL ENGINEERS IN THE UNITED STATES NAVY.

Under date of June 30th, 1904, the Navy Department has issued the following list of rules regarding the examinations:

No person shall be appointed who is less than 23 or more than 28 years of age.

Candidates for appointment shall be examined as to their physical fitness by a board of medical officers of the navy and as to their mental and professional qualifications by a board of such officers as the Secretary of the Navy may designate for the purpose.

The physical examination shall precede the mental and professional, and if a candidate is found physically unfit for appointment he shall not be further examined.

Application for permits to be examined must be made to the Secretary of the Navy, and must be accompanied by testimonials as to character, evidence of American citizenship, evidence of having received a degree in the civil engineering course of some professional institution of good repute, with a record of at least two years' practical experience as a civil engineer. No person shall be admitted who has been examined at any time within one year prior to the date of this examination and failed to meet the professional requirements.

The mental and professional examination will be competitive and in writing and will comprise such subjects as the following: Testimonials and adaptability; English grammar and composition; elementary physics; elementary geology; drawing; arithmetic; algebra; geometry; trigonometry; analytical geometry; differential and integral calculus; applied mathematics, including mechanics of solids and fluids and strains in structures; electricity; construction materials; engineering constructions, such as workshops, steam and electrical machinery, quay walls, wharves, sewers, yard railways, pavements, water distribution, foundations, etc.; surveying (topographical, trigonometrical, and hydrographical) and mapping; instruments, their use and adjustment.

Candidates who pass satisfactorily will be arranged by the board in the order of their relative merit as determined by such professional examination, and appointments will be made in such order, but no candidate will be considered as having passed a satisfactory examination, or be appointed who does not attain a general average of 80%.

The examination will be held beginning August 1st, 1904, at the navy yard, New York, N. Y., and candidates to whom permits may be issued should present themselves before the medical officer or board at that place at 10 o'clock A. M. on that date. The professional examination will occupy about ten days.

PREVIOUS EXAMINATION PAPERS.

SEPTEMBER 6, 1898.

1. Name in full.

2. Whether or not a citizen of the United States of America.

3. When and where born; age in years and months on Sept. 6, 1898.

4. Present address in Washington.

5. Usual address, town, county and state.

6. Statement in detail of engineering instruction received.

7. Tabulated statement of positions held; time in each; detailed description of work.

GRAMMAR.

1. Name the principal marks used in punctuation and give their relative value and uses.

2. What mood most frequently occurs in specifications, and what moods and tenses may be used?

3. "Purchasing pay officers will be furnished with funds for the payment of bills upon requisitions prepared in the office of the Paymaster General, due notice of the drawing of which will be sent to the purchasing officer."

Analyze the above sentence. Parse the underscored words, giving part of speech, number, person, degree, mood, tense, etc., so far as applicable.

4. Give a list of the relative pronouns. Give a list of the prepositions of place and direction. What are the regular endings of participles?

5. Name the most frequently used conjunctions; divide them into classes, and define the characteristics of each class.

COMPOSITION.

Give a description, from 300 to 500 words in length, of some engineering work with which you are familiar, and upon which you have been employed.

ARITHMETIC.

1. Given three buildings 129.2 ft., 191.4 ft., and 295.8 ft., respectively, c. to c. of end posts, in which it is desired that the panel

lengths shall be the same and as long as consistent with this condition, what is the length of panel to be used?

2. The length of a bridge panel is 16 ft. $\frac{1}{32}$-in., c. to c. The depth of truss is 24 ft. c to c. of chords. What will be the center length of an eye-bar providing for a 6-in. pin and a clearance of $\frac{1}{50}$-in. in each eye of the bar?

3. A rectangular prism has a base of 496 by 558 ft. and a height of 186 ft. What is the edge of a cube having the same volume?

4. Find the weight in kilograms of a hexagonal prism of a substance whose specific gravity is 2.3 and whose dimensions are 554.256 mm., on each edge of the hexagon, and 3 m. perpendicular distance between the hexagonal end faces?

5. A square test-piece, originally 8 in. between measuring points, measures 10.35 in. after fracture. What is its percentage of elongation? Its original area was 0.567 sq. in., its rectangular dimensions at fracture are 0.493 in., and 0.562 in. What is its percentage of reduction of area at fracture? What were its original dimensions?

6. What is the cost per cubic yard of finished concrete in place when composed of the following ingredients and worked by the following labor?

16 cu. yd. of silica sea-washed gravel, voids, 37%, at $1.45 per cu. yd.

Sand used in excess to extent of 22%, voids, 43%, at $0.85 per cu. yd. Portland cement used in excess to extent of 16%, $1.96 per bbl. Labor, $\frac{1}{10}$ superintendent at $6.00; $\frac{1}{2}$ leading man at $3.76; two second-class masons at $3.28; four first-class hod carriers at $1.76; two third-class laborers at $1.28, and two fourth-class laborers at $1.04.

Physics.

1. Define the term "hygrometric condition of the atmosphere," and describe a method of determining this condition. What trouble is experienced in compressed-air machinery on account of moisture in the air?

2. How is sound transmitted from point to point, and at what rate in an ordinary occupied hall? Show how you would construct a building so as to prevent sound passing from one room to another. Explain how such a construction attains the desired end.

3. Draw diagrams to show the arrangement of lenses, the axes and the paths of rays of light in an ordinary direct telescope, an

inverted telescope and a field glass. What advantage has the second over the first?

4. Define specific heat, and state which is greater, that of gases at constant pressure, or at constant volume. What work is a measure of the difference? Show how to measure the temperature of a furnace, when the only tools at hand are a pocket thermometer, reading to $\frac{1}{5}^\circ$ between 20° and 120° Fahr., and such articles as can ordinarily be found in a country general store.

5. Draw a heat engine diagram, and indicate at what points entrance and exhaust parts were opened and closed, which curves are isothermal, which are adiabatic, and state upon what the theoretical efficiency of a heat engine depends.

6. An alternating current dynamo delivers 20 amperes under 140 volts at the terminals of a step-up converter, the efficiency of the converter being 68%, what current will be delivered in the line at a voltage of 3 000? Allowing 3% loss in the line up to the terminals of a converter of 85% efficiency, which delivers current to a lamp circuit of 56 volts, what current flows in the lamp circuit? What is the efficiency of distribution from the dynamo terminals of the step-up converter? Describe the principle and construction of the converters. What is the most prominent mechanical difference between the construction of alternating-current and direct-current dynamos?

Geology.

1. Explain the formation of anthracite and bituminous coals, petroleum, and natural gas.

2. What are the principal ores of iron, and about what per cent. of metal does each contain?

3. What is the composition of granite? Of gneiss? Of cyanite?

4. What are artesian wells? Whence is drawn their supply? In what formation would you expect to find artesian water? What is the difference between ordinary driven wells and artesian wells?

5. Explain amorphous and laminated structure in building stones, and state what precautions should be used in laying each kind.

Algebra.

1. Find the value of

$$\frac{\sqrt{(a^2+x^2)}+x}{\sqrt{(a^2+x^2)}-x}, \text{ when } x = \frac{(6-c)a}{2\sqrt{bc}}.$$

2. Divide the product of $x^2 + 3x + 2$, $x^2 - 5x + 4$, $x^4 + 5x^2 - 14$, by the product of $x^2 - 1$, $x^2 - 2$.

3. Extract the cube root of $27x^4 - 27x^5y - 45x^4y^2 + 35x^3y^3 + 30x^2y^4 - 12xy^5 - 8y^6$.

4. Find values of x and y by solving the expressions,

$$x^2 + y^2 = 136 \text{ and } x^2 - 24y = 11.$$

5. Define logarithms and explain their use in extraction of roots and determination of powers of numbers.

Geometry.

1. Using the double-circle method, construct graphically an ellipse whose major and minor axes shall be in the ratio of 3 to 2.

2. Find graphically the center of a given circular arc. Explain the geometrical reason for the method.

3. Bisect the angle A of any triangle $A\,B\,C$ at A, draw a perpendicular to the bisectrix. Prove that the sum of the distances from any point P on this perpendicular to B and C is greater than the sum of $A\,B$ and $A\,C$.

4. Reduce, graphically, the area given to a right-angled triangle of equal area. Give geometrical proof of the method.

5. Prove, geometrically, that the frustum of a pyramid is equal to the sum of three pyramids whose height is the height of the frustum and whose bases are the bases of the frustum, and a mean proportional between them.

Trigonometry.

1. Given, $\sin a = 0.5$; $\cos a = 0.87$; $\sin b = 0.8$; $\cos b = 0.65$. Find $\sin (a - b)$; $\cos (a + b)$. Is the sum of a and b greater or less than 60°? Show how this can be proven.

2. Find the value of $\tan (a + b)$ when $\tan a = 1$ and $\tan b = 1.4$. Is the sum of a and b greater than 30°, greater than 90° and greater than 135°?

3. Given a triangle whose sides are 8, x and y, and whose angles have the following functions:

	Sin	Cos	Tan	Cot
a	0.82	0.57	1.43	0.70
b	0.90	0.44	2.05	0.49
c	0.87	0.48	1.80	0.55

Find the lengths of the other sides.

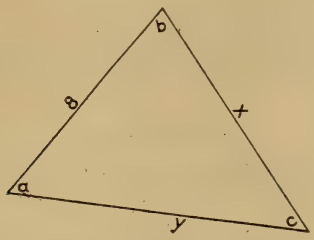


FIG. 1.

4. Represent, graphically, the sine, versed sine, cosine, tangent, cotangent, secant and cosecant of an arc of 60°. Find their values.

5. Prove that in a circle the sine of 90°, the tangent of 45° and the chord of 60° are all equal.

ANALYTICAL GEOMETRY.

1. Prove that every equation of the first degree between two variables is that of a straight line.

2. Given the equation of the circle $x^2 + y^2 = 25$, find the equation of a tangent at the point 4, 3.

3. Deduce the equation of a parabola referred to rectangular co-ordinates, origin at the vertex.

4. Give the equation of the equilateral hyperbola referred to its asymptotes, these co-ordinate axes being rectangular. Where is this equation of practical use?

5. Given the general equations of line and circle:

$A\,x + B\,y + C = 0$, and $x^2 + y^2 + A\,x + B\,y + C = 0$.
prove analytically that the common chords of three intersecting arches intersect in a common point.

DIFFERENTIAL CALCULUS.

1. Differentiate $a\,x^2$ and prove the result.

2. Differentiate $\frac{a}{x^2} \log A\,x$.

3. A square piece of sheet metal is to have a square cut out from each corner, and the four projecting flaps are to be bent up so as to form a tank. What must be the side of the part cut out that the volume of the tank may be a maximum.

Integral Calculus.

1. Find $\int (a - 4x)^2\, dx$.

2. Deduce the general formula for the area of a plane figure in polar co-ordinates. Find the area of a circle by this formula.

Instruments.

1. Draw a diagram which will show the principal features of a plain transit. Give the adjustments in order and describe them.

2. Draw a diagram which will show the principal features of a Y-level. Give the adjustments in order and describe them.

3. Describe the surveyor's compass and state in what important respect the mariner's compass differs from it.

4. Having no leveling instrument or leveling tool at hand, construct a level of sufficient accuracy for ordinary drainage work.

Drawing.

1. Draw a plan and two elevations of a pile of blocks as follows: The lower 3 by $1\frac{1}{2}$ by $\frac{1}{2}$ in., lying on the horizontal plane, its long edge making an angle of 30° with the vertical plane; the second of the same section, but 1 in. shorter, lying on the first and making with it an angle of 45°; the third, a rhomboid, with largest edge 1 in., lying upon the second. Show the shade lines, the light rays making an angle of 45° with both the horizontal and vertical planes. Show shadows.

2. Draw in isometric projection a cube of 8 in. edge. Show a square hole with 1 in. edge through the middle of the cube from top to bottom. Show circular holes 1 in. diameter through the cube from the centers of the other faces. Show recess 2 in. diameter and $\frac{1}{2}$ in. deep around hole on left-hand side. Show square collar $\frac{1}{2}$ in. high, 1 in. internal diameter and 2 in. external diameter, around hole on right-hand face.

3. Make a finished tracing of either 1 or 2.

4. From the drawing furnished, state each element and its function in the machine.

5. Make a finished topographical map from the sketch furnished.

Surveying.

1. Fill out the notes given below; correct the readings for curvature and refraction, and find the elevation of the second bench mark:

Sta.	Dist. fr. level.	B. S.	H. I.	F. S.	Elev.
B. M., No. 1.............	100 ft.	4.522	......	......	25.373
A.	500 ft.	.....	......	11.167	......
A.	75 ft.	1.277	......	......	......
B. M., No. 2.............	450 ft.	.....	......	7.423	......

All readings are in feet.

Describe method of making and locating bench marks in a wild country.

2. A bench mark on shore reads 24.96 ft., referred to Cairo datum; this datum is 21.26 ft. below mean Gulf level; the zero of a standard tide gage is 20.91 above mean Gulf level. Starting from the bench mark, set a tide gage with Gulf level for zero. Tide gage reads 3.7 ft.; reduce a sounding of 59 ft. to zero of the standard gage.

3. Show how to make a topographical survey of the hill indicated (Fig. 2), and determine the number of cubic yards it contains. Assume any elevations and distances you may choose.

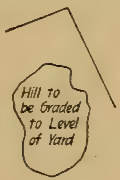


FIG. 2.

4. Having a property located on a river front, as indicated (Fig. 3), locate soundings and the course and rate of current, having only one transit. Graduate a sounding line for use on the above work. Describe a float for use in ascertaining the discharge of a stream.

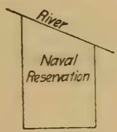


FIG. 3.

5. Having a field bounded by the lines passing between the points *A, B, C, D, E, F, G, H, I, J* (Fig. 4), all of which are about 5 ft. above the level of high water in the river; dense woods in the areas indicated; a hill 35 ft. high; a wall 20 ft. high; a swamp and a slough in the indicated positions; and the points *I* and *J* marked by piles in the river; show how lines would be traced and their

lengths and directions determined. The branch of the slough where it is crossed by the lines *H I I J* and *J A* are about 700 ft. long.

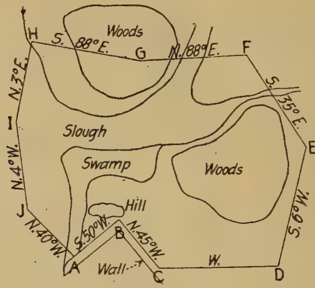


FIG. 4.

GRAPHICS.

1. Given a beam 25 ft. in length, and weighing 150 lb. per ft., with weights distributed as shown in sketch (Fig. 5); find graphically the amount and location of the greatest bending moment. Also show graphically the shear. Find both analytically.

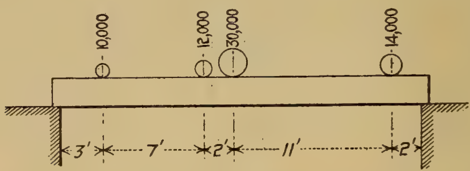


FIG. 5.

2. Determine graphically the stresses in the members of the roof truss shown in diagram (Fig. 6), the load, including the weight of the roof, to equal 45 lb. per sq. ft. Trusses to be 24 ft. c. to c.

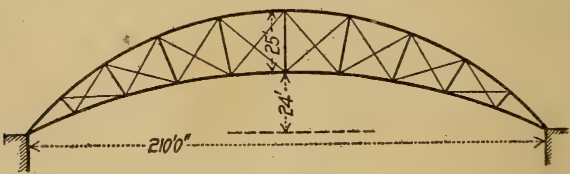


FIG. 6.

GENERAL PRINCIPLES OF MECHANICS.

1. A train's speed is 45 miles per hour. Its wheel base, uniformly distributed, is 8 ft. The curve upon which it is running is of 1 000 ft. radius. The load upon each axle is 14 000 lb. Ties are spaced

2 ft. centers. The side resistance of a spike is 1 200 lb. How many spikes are required in each tie to make the factor of safety 4?

2. Show how to find, experimentally, the center of gravity of a shape of irregular section (Fig. 7), where the end is cut in a plane normal to the longitudinal axis of the piece and can be easily reached for inspection and measurement. Let the section be that shown in the diagram. Find, also, the center of gravity of this section analytically.

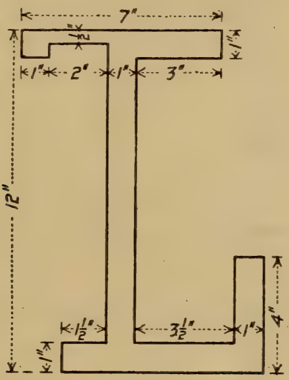


FIG. 7.

3. Find the moment of inertia of the above section about an axis through the center of gravity, and parallel with the long edge.

4. Given a pile which has been driven 40 ft., and which is 6 in. in diameter at the lower end and 13 in. at the surface of the ground; what is the frictional resistance per square inch of the pile if the next blow of a 3 000-lb. hammer, falling freely 20 ft., sinks the pile 1 in.?

5. A car starts down a grade of 1%. What is the coefficient of friction? What kinds of friction exist, and at what points? Which kind is the greater in this case?

MECHANICS OF FLUIDS.

1. Find entire pressure and center of pressure on a trapezoidal gate, the upper edge of which is 80 ft. long; the lower edge 65 ft.; the depth of water being 28 feet.

2. A wooden sphere, the diameter of which is 8 in. and the specific gravity 0.75, is placed in water. To what depth will it sink?

3. Give the Chezy formula; explain the meaning of all the terms entering into it; state what modifications, if any, you would make in its use.

4. Make a diagram of and explain the principle of action of the hydraulic ram.

5. Explain the purpose, principle and action of an accumulator.

Cranes.

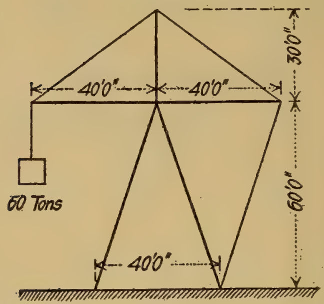


Fig. 8.

1. Determine the stresses in the members of this crane (Fig. 8), both analytically and graphically.

Chimneys.

1. A steel chimney 150 ft. high and 9 ft. in external diameter is to be constructed. What number of $\frac{3}{4}$-in. rivets will be required in the horizontal joint 30 ft. above the ground, the wind pressure being assumed at 40 lb. per sq. ft.?

Constructional Materials.

1. Provided Indiana limestone and the commonly used brownstone cost the same per cubic foot, which would be preferable for ashlar work in the vicinity of New York or Boston? Why?

2. For polished decorative work on buildings, what stone would you use for outside work? What for interior work? For what work would you use bluestone?

3. How are bricks classified? What kind would you use for house fronts? What in boiler settings? What in steel chimney linings? What in pavements?

4. What cement would you use where it is desirable to have as great strength as possible? What where less strength is required and economy in first cost is essential? What tensile strength would you expect each to show in test briquettes at the end of seven days? What is the difference in composition and action of these cements?

5. Of what is concrete made? What are the proportions commonly used? How should it be mixed? How put in place? On what does its value depend? What precautions should be taken in its use?

6. What are the principal kinds of glass used in ordinary building construction? What would you require for a six-light sash, 12 by 15 in. panes, to be used in a good store house? What glass would you use in good skylights? What are the standard sizes of tin roofing plates? Is IC or IX the heavier plate? How should tin be laid on a steep roof? How on a roof of little pitch?

7. Describe the characteristics of cypress, yellow pine, white pine, hemlock, spruce, poplar, ash and oak.

8. State what should be used for each of the following purposes: Norfolk bearing piles; Boston bearing piles; wales; first-class floor beams and joists; door and window trimmings; office and house wainscoting; sheathed partitions, and wooden ceilings.

9. How does prime inspection differ from mercantile inspection?

10. What is the composition of the best paints for wood, iron and tin surfaces? What would be used on stained uncarpeted floors? What on hardwood trimmings to show the natural color and grain?

11. Name the principal metals used in engineering work and give their range of strength in tension. Name the common elements occurring in metals of engineering and describe their effects upon the physical properties.

12. What is galvanized iron? In what form is it commonly used for roofs and sidings of buildings? In what for gutters and downspouts? Thickness commonly used? Usual sizes of manufactured sheets? Upon what does its durability depend?

13. In what form is copper used in building? What are its advantages over tin or galvanized iron? What two kinds are used? What are the characteristics of each?

14. What considerations of theory and practice determine the sections of the usual commercial forms of structural iron and steel?

Engineering Construction.

1. Draw diagrams of sections of the following floors: End construction, hollow tile; side construction, porous terra cotta; buckle plates; slow-burning mill construction.

2. Describe the construction of each of the above floors, and its action under fire and water and under repeated blows.

3. Design a flight of stairs, 4 ft. wide, between two floors 14 ft. apart vertically; strings to be of steel and treads of yellow pine.

4. In a 100-ft. plate girder, having continuous flange angles and a web consisting of five plates, explain why holes may mismatch after being correctly laid off and accurately punched. How may this difficulty be avoided?

5. What are the requisites of good machine riveting? Why is machine riveting preferred to hand riveting? How can loose rivets be detected?

Pavements.

1. Describe Telford and Macadam roads. Make sketches of cross-sections, showing the construction of each. What amount of crowning would you give? What is the best stone to use and why?

2. Describe the construction of the best quality of granite block paved streets, of brick paved streets, and of asphalt paved streets.

3. Under heavy traffic, can a wooden pavement be used economically? If so, how heavy must the traffic be? Show the best construction for wood pavements.

Dry Docks and Quay Walls.

1. Draw the transverse section of a concrete dry dock 90 ft. wide on the floor and 39 ft. deep, with blocks 4 ft. high and top of blocks 30 ft. below high water. Determine the thickness of concrete floor which will be required if water under bottom of dock is in connection with that outside the gates and if the weight of the floor is to be depended upon to balance the existing pressure. Show a method of building a floor in a dock of this width which will be more economical.

2. Sketch a section through a floating dock to take ships drawing 18 ft. of water.

3. Design a quay wall to be built under the following conditions: Mean rise and fall of tide, 12 ft.; extreme rise and fall, 19 ft.; bottom slope, about 1:10, running out to depth of 35 ft. at extreme low water; character of bottom, sand and indurated gravel into which timber piles can be driven by impact about 6 to 8 ft.; the teredo is very bad, destroying timber in from one to three years; timber plentiful; material for fill, sand and gravel from dredging or from the neighborhood; broken stone obtainable from quarry near by; depth of water alongside to be at least 20 ft. at extreme low water, and 30 ft. at a distance of 20 ft. from the wall; dredged slopes have stood for years in deep water at 1 on 1.

WHARF.

1. Given conditions as shown in the subjoined sketch (Fig. 9), design a wharf alongside of which ships 400 ft. long, drawing 28 ft. of water, can lie.

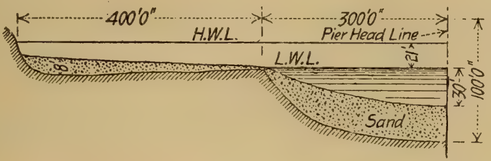


FIG. 9.

BOILERS, ENGINES AND ELECTRIC PLANT.

1. Draw a longitudinal diagram of a brick boiler-setting for a horizontal return tubular boiler in which the fire-sheet is extended beyond the head tube-sheet to form the bottom and sides of the smoke connection.

2. State what ratio should exist between the area of grate and the area over bridge wall. What is a good ratio of heating surface to grate area?

3. Where should hand and man-holes be located? Draw sketch of man-hole cover, and show how it is fastened in place to insure a steam-tight joint. How many back-stays should be provided for an 18-ft. tubular boiler, 60 in. in diameter?

4. Make a diagram of and explain the principle and action of an injector on a steam boiler. Where is the exhaust pump located in a jet condenser, and why?

5. Give essential differences between engines for mills and for electric light plants.

6. Draw a section of a brick chimney 100 ft. high, having a flue 4 ft. square, on a concrete foundation placed upon a good bed of gravel which is 50 ft. thick.

7. Illustrate by diagram the three-wire system of electric distribution. State what voltage you would specify for generators, motors, arc lamps, and show how they would be connected in the same three-wire system. Explain the use of feeders.

MASONRY AND FOUNDATIONS.

1. What are footing courses and what purpose do they serve? Draw diagram showing stone footing courses for a 32-ft. wall, and brick footing courses for a 24-ft. wall.

2. Design a flying buttress to give a clear space of at least 12 in. wide by 15 ft. high between it and the building, and to take the thrust of 125 000 lb. at an angle of 45° with the horizon at 25 ft. above the surface of the ground.

3. Design an abutment for a double-track railway bridge to span a street 60 ft. wide, to give a clear headway of 15 ft. and to be located on a good gravel foundation.

4. Draw diagram of and explain the construction of a foundation such as is much used in Chicago to support a heavy steel frame building on a light compressible soil.

5. Design a foundation for a column to be placed at A (Fig. 10) to support a load of 350 000 lb.

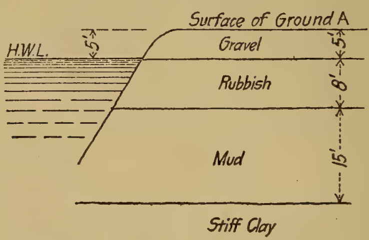


FIG. 10.

YARD RAILWAYS.

1. Draw a diagram to show a system of construction when a girder rail is used. What objection is there to the use of girder rails in the streets of navy yards where ordinary freight cars can be hauled over them?

2. Show a system of track construction in which T-rails are used in paved streets in such a way as not to interfere with the ordinary wheeled traffic.

3. Put a light curve in a T-rail track without the use of a rail bender.

4. Draw diagram of a turnout, using a safety switch and bolted frog.

5. Illustrate by diagram and describe apparatus necessary to transfer freight cars from floats to yard tracks, the coping level being 5 ft. above mean high water, and the mean rise and fall of the tide being 6 ft.

Water Distribution and Sewers.

1. A yard supply is drawn from springs flowing, approximately, 100 000 gal. per day. Design a well so that this entire flow can be utilized by a pump working 8 hours per day. Sketch plan and section of well.

2. Given a yard supply as in the above question; design a steel tank or tanks to hold 500 000 gal., sketching plan, section and elevation, and showing foundation on slightly compressible soil, thickness of metal, size and spacing of rivets. Give also details of pipe connections.

3. The above tank or tanks being located on a hill 200 ft. above the working portion of a yard and three-quarters of a mile distant, what thickness would you give to the cast-iron distributing mains, from tank to tide-level, for 4-in., 6-in., and 8-in. pipe?

4. A large, circular city sewer, 6 ft. in internal diameter, discharges into the water fronting a navy yard. Design a diverting sewer of semi-circular section, with pile and timber foundation, to carry the sewage through the yard to its boundary. The sewer to be strong enough to support the passage over it of the heaviest weights likely to be met with in navy yards. The junction with the old sewer to be arranged to permit the use of the latter for storm waters. What change in bottom and foundation would you make where it passed over a compact bed of gravel of considerable thickness?

5. Describe methods of giving grade, and the laying of pipe sewers.

EXAMINATION QUESTIONS FOR EXAMINATION HELD DECEMBER, 1900, TO FILL VACANCIES IN THE CORPS OF CIVIL ENGINEERS, U. S. NAVY.

Personal Data.

(*a*) Name in full. (*b*) Whether or not a citizen of the United States of America. (*c*) When and where born. Age in years and months on December 17, 1900. (*d*) Local address while taking examination. (*e*) Usual address, town, county and state. (*f*) Statement in detail of engineering education received. (*g*) Tabulated statement of positions held, time in each, detailed description of work.

Drawing Materials Which Should Be Brought In by Candidates.

Drawing board, about 15 by 20 in.; T-square; triangles, 30° and 45°; thumb tacks; a plain set of instruments; drawing pencils, mapping pens; red and black drawing inks; scales; drawing paper, white and detail, of each about 4 sq. ft.; tracing cloth, about 4 sq. ft. All drawings must be made to trim to 8½ by 14 in., with a proper margin for binding.

English Composition.

Write a letter to the Board, about two pages in length, stating clearly and concisely what in your opinion is the most desirable branch of the civil engineering profession to be followed in civil life and why.

English Grammar.

1. Correct the following sentences if necessary and give reasons: (*a*) Were it true that a sufficient strata of clay exists at that level Smith and myself should have the information. (*b*) It is they whom our thoughtless friend would offend if he was present at the time. (*c*) To myself it has occurred that were he in a syndicate he would neither be so outspoken or so bitter in his opposition against such organizations. (*d*) Though he may try to impress on his auditors his own wide experience, he only succeeds in earning for himself the ridicule of those of even superficial education. (*e*) Well as he appears since his confinement with typhoid, he always complains of feeling badly.

2. Analyze the following sentence: Though he served or tried to serve Russia as faithfully as he had served America, the conditions he encountered were not adapted to his temperament.

3. Give a tabular synopsis of the voices, moods and tenses of verbs, and illustrate by the first person singular of each of the following: Begin, get, eat, draw, bring.

4. State the rule for the usual formation of the plural of nouns and illustrate by three examples. State the plural of the following: Mouse, deer, man, woman, foot, swine, goose, vermin, box, cow, means, potato, wolf, ox, chimney, fairy, elf.

5. Classify and decline the following pronouns: I, whoever, that, you, it, myself.

Arithmetic.

1. Find the least common multiple of the following numbers, giving all work: 668304, 2100384, 12285.

2. Below are given the rod readings at the corners of 10-ft. squares taken over a portion of a borrow pit. Determine the amount excavated in cubic yards and also the side of a square bin 10 ft. deep which will just contain the excavated material. The rod readings are in feet.

10	6	3	2	7	4	5	10	6	7	3
4	4	5	6	3	7	5	6	4	5	4
7	3	6	10	12	7	9	10	5	2	
	6	8	16	20	25	12	8	4	6	
	5	8	5	13	24	14	6	7		
		4	2	9	11	7	3	5		
		10	6	4	3	5	6			
				5	2	4	8			

3. Find the partial and total feet, board measure, in the following bill of timber: 71 pieces 12 in. × 14 in. × 22 ft.; 16 pieces 12 in. × 12 in. × 30 ft.; 27 pieces 10 in. × 12 in. × 20 ft.; 116 pieces 6 in. × 8 in. × 18 ft.; 317 pieces 3 in. × 14 in. × 24 ft.; 18 pieces 3 in. × 10 in. × 22 ft.; 74 pieces 2 in. × 8 in. × 16 ft.; 506 pieces $1\frac{1}{2}$ in. × 12 in. × 24 ft.; 117 pieces $1\frac{1}{4}$ in. × 6 in. × 16 ft.; 221 pieces 3 in. × 4 in. × 18 ft.

4. Determine the cube root of the following, giving all work: 57.825915363.

Algebra.

1. Reduce to its lowest terms:

$$\frac{8\,a^2\,b^2 - 10\,a\,b^3 + 2\,b^4}{9\,a^4\,b - 9\,a^3\,b^2 + 3\,a^2\,b^3 - 3\,a\,b^4}.$$

2. Find the value of:

$$\frac{b\,c\,d}{(a-b)\,(a-c)\,(a-d)} + \frac{c\,d\,a}{(b-c)\,(b-d)\,(b-a)} + \frac{d\,a\,b}{(c-d)\,(c-a)\,(c-b)} + \frac{a\,b\,c}{(d-a)\,(d-b)\,(d-c)}.$$

3. Extract the cube root of:
$27x^6 - 27x^5y - 45x^4y^2 + 35x^3y^3 + 30x^2y^4 - 12xy^5 - 8y^6$.

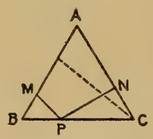
4. Solve the following equations:
$3x^2 + 165 = 16xy \qquad 7xy + 3y^2 = 132$

5. Expand to six terms:

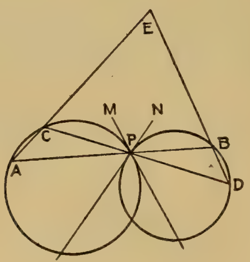
$$\frac{1}{(2a - 3x)^3}.$$

Geometry.

1. If from a variable point P in the base of an isosceles triangle $A\ B\ C$, perpendiculars $P\ M$, $P\ N$ to the sides are drawn, the sum of $P\ M$ and $P\ N$ is constant and equal to the perpendicular from C upon $A\ B$. See the subjoined figure.



2. Demonstrate that if through P, one of the points of intersection of two circumferences, any two secants $A\ P\ B$ and $C\ P\ D$ are drawn, the straight lines $A\ C$ and $B\ D$ joining the extremities of the secants, make a constant angle E, equal to the angle $M\ P\ N$ formed by the tangents at P.



3. Find the lateral area of a frustum of a right cone of altitude 10, diameters of bases 8 and 12, and prove the formula used.

4. Prove that in a regular tetrahedron, three times the square on an altitude equals twice the square of an edge.

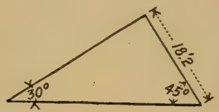
5. Define spherical excess and prove that a spherical triangle equals a lune whose angle is half the spherical excess on the triangle.

Trigonometry.

1. Express all the other trigonometric functions in terms of the sine and prove the expressions.

2. Develop the expressions for the sine of the sum and the sine of the difference of two angles. Also develop

$$\text{Sine } (a + b + c).$$



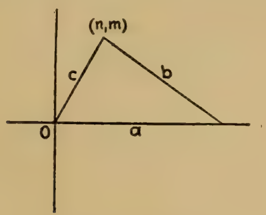
3. Find the missing values of the angle and sides in the triangle shown and derive the formula used to obtain the sides.

4. Give Napier's rules of circular parts and illustrate the same by a diagram.

Analytical Geometry and Calculus.

1*a*. Find the equation of the straight line which passes through two given points.

1*b*. Demonstrate that the straight lines drawn from the angles of a triangle to the middle points of the opposite sides meet at a point. Use the subjoined figure and notation.



2. Deduce the general polar equation of the circle and show its form when the center is at the pole.

3. Demonstrate that from any external point two tangents can be drawn to an ellipse, and determine the equation of the chord of contact.

4. Discuss by differential calculus the curve represented by

$$y = \frac{a^2 x}{a^2 + x^2}.$$

5. Find by integration the area between the parabola

$$y^2 = ax$$

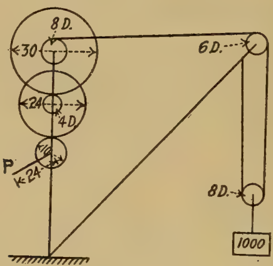
and the circle

$$y^2 = 4ax - x^2.$$

Show all work.

Physics.

1. Neglecting friction, find the power to be applied at the end of the crank, and also the rate of hoisting the load when the crank is revolved four times per minute.



2. Draw a diagram of essential elements of a phonograph, describe the method of using the instrument, and give the principles upon which its operation depends.

3. Describe one of the more common forms of commercial ice machines, and give the principles and cycle of operations.

4. Describe the phenomena of the rainbow. Show when they may occur, and sketch a diagram showing the paths of rays of light from the sun to the eye of the observer.

5. Draw diagrams of a reflecting galvanometer and a Wheatstone bridge. Show how to use the instruments to find the resistance of a coil whose resistance is greater than the combined resistance of the bridge.

Geology.

1. What agencies are now at work to modify the structure of the earth crust? Explain the formation of soil. Why does soil accumulate more rapidly on lowlands than in mountainous regions?

2. State the origin of granite, quartz, clay, limestones, corals, sandstones, quartzite, coal, lignite.

3. What law governs the increase of erosive power with velocity in running streams? Give your authority.

What is an estuary? Give mode of formation.

What are faults? How caused? What is their effect in the exploitation of mines? Give illustrative diagrams.

4. Explain the origin of icebergs.

State the principal stratified building stones. What precautions should be taken in laying them in a structure?

What is the most common igneous rock used in construction?

What is the most common structure of basalt? What is the generally accepted cause of this formation?

5. What is the source of aluminum, its method of extraction, its principal alloy, its most notable characteristics, the principal drawbacks to its general use?

What is galena? Malachite?

What is the composition of hematite, magnetite, limonite, pyrites?

Surveying.

1. Find the area of the following piece of ground, determining the length of the missing course and also its bearing, giving the latter by means of its tangents:

a to *b*, N., 20 ft.; *b* to *c*, N. 60° E., 500 ft.; *c* to *d*, E., 300 ft.; *d* to *e*, S. 45° W., 400 ft.; *e* to *f*, S. 15° E., 400 ft.

2. Give day and night methods of determining the true meridian. State all instruments, tables, etc., required for the work, explain in detail the methods to be employed, and the corrections to be applied to observations.

Discuss the relation between magnetic and true meridians as to time and locality.

3. Give detailed description of the method of making a hydrographical survey of a tidal river at least 500 ft. across.

4. Given a level in perfect adjustment, describe in detail the method to be employed in running an accurate line of levels, several miles in length, over an irregular country. State the precautions to be taken and the corrections to be applied for climatic and other reasons.

5. Describe the method you would employ in making a topographical survey of a small area of great value to be improved at a cost which depends largely upon the conformation of the surface.

Describe the method you would employ in making a topographical survey of a large area of forest, swamp and lake, the value of the property being relatively small.

Instruments.

1. Draw a diagram which will show the principal features of a plain transit. Give the adjustments in order, describe them, and illustrate by diagrams.

2. Draw a diagram which will show the principal features of a Y-level. Give the adjustments in order, describe them, and illustrate by diagrams.

3. Describe the stadia, illustrate by diagram, show its use, and deduce all formulæ needed for its operation.

4. Describe the construction and use of the surveying sextant and illustrate by diagram.

Show how the three-arm protractor is used in plotting locations determined by sextant angles.

5. Draw a diagram of a mercurial surveying barometer, showing all essential details for adjustment; describe proper methods of transportation and use of instrument, and state what tables you would use in working up readings.

Drawing.

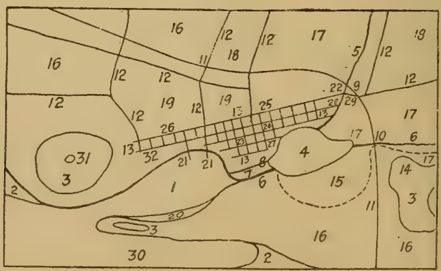
1. Draw plan, one elevation and section parallel to vertical plane of the following:

A hexagonal block, with side 2 in. and height the same, stands on the horizontal plane with its centre $3\frac{1}{2}$ in. from the vertical plane. Through this block is a circular hole $1\frac{1}{2}$ in. in diameter. Standing with the center of its base to the left and in a direction from the center of the block which makes an angle of 30° with the vertical plane, is a right cone with base 3 in. in diameter and height 5 in. Show shade lines, shades and shadows, the rays of light coming from the left and making an angle of 45° with both horizontal and vertical planes.

2. Make a finished tracing of the above drawing.

3. Make a perspective of the above blocks with shades and shadows.

4. Make a finished topographical map from the accompanying sketch. Reference numbers as follows:

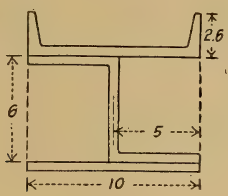


1 bay.
2 sand.
3 hill.
4 pond.
5 creek.
6 river.
7 canal.
8 lock.
9 bridge.
10 drawbridge.
11 railroad.
12 roads.
13 streets.
14 quarry.
15 swamp.
16 woods.
17 grass.
18 orchard.
19 cultivated land.
20 marsh.
21 piers.
22 railroad station and telegraph office.
23 post-office.
24 court-house.
25 church.
26 blacksmith's shop.
27 woolen mill.
28 sawmill.
29 grist-mill.
30 anchorage.
31 light-house.
32 hotel.

Mechanics of Solids.

1. In the sketch shown the plate is $\frac{1}{2}$ in. thick. The area of the 10-in. 15-lb. channel is 4.46 sq. in. Its c. of g. is 0.639 in. from back of web. Its moment of inertia parallel to the web is 2.30 and perpendicular to web is 66.9. The area of the 6-in. 15.6-lb. Z-bar is 4.59 sq. in. Its moment of inertia, neutral axis through c. of g. parallel to web, is 9.11 and perpendicular to web is 25.32.

Find the center of gravity of the combined section, its moment of inertia and radius of gyration about a pair of rectangular axes, parallel and perpendicular, respectively, to the web of the Z-bar and passing through the c. of g. of the section.

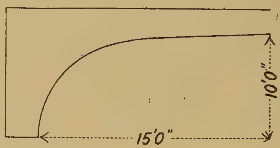


2. A medium steel shaft, 10 ft. long and 4 in. in diameter, has a gear wheel 6 ft. in diameter keyed on one end. Using ordinary factors of safety for running shafting, what is the greatest horsepower which can be transmitted? Give values for ultimate strength and safety factor used.

3. A standpipe, 80 ft. high and 30 ft. diameter, is constructed of soft steel plates, with lapped joints. What must be the thickness of the bottom course of side plates, using the customary values for the safe strength of the material? Seven-eighths-inch rivets being used, what must be the spacing of rivets in vertical seams in this course?

4. Design a reservoir wall of Portland cement concrete, the inner face to be vertical and the height to be 20 ft., the outer face to be uniformly battered; water level, 2 ft. below top.

5. Illustrate by means of the following diagram the method and principles of design of a stone arch, supplying any further lines necessary for the purpose.



MECHANICS OF FLUIDS.

1. Find the total pressure on the surface of a material cylinder of length 3 ft. and diameter 2 ft., its axis parallel to the surface of the water, in which it is immersed to a depth of 10 in. from surface to axis.

2. Explain the turbine and impulse wheels; make a diagram of each and show when each should be used.

3. Give the formula for the flow of water through a pipe $\frac{3}{4}$ full and discuss it.

4. Let h be the total head on a pipe, h' the head lost in entrance, h'' that lost in friction, h''' that lost in valves, bends, etc.; deduce a formula for velocity and one for discharge from a circular pipe.

5. Derive and discuss the formula for the flow of water through a rectangular vertical orifice, its upper edge being coincident with the surface; a rectangular vertical orifice, its upper edge parallel to but below the surface of the water; a circular vertical orifice below the surface of the water.

PAVEMENTS.

1. Make sketches and describe in detail the design and construction of an asphalt paved residence street 120 ft. wide between house lines.

2. Make sketches and describe in detail the design and construction of a granite block paved street 50 ft. wide between store houses having the receiving and delivering doors on both sides of the same. Include a crossing.

3. Make sketches and describe in detail the design and construction of a brick paved street 80 ft. wide in a retail district, the street

to have a double-track for street cars. Width to be between store fronts.

4. Make sketches and describe in detail the design and construction of a macadam park drive 40 ft. wide.

5. Make sketches and describe in detail the design and construction of a gravel country road through a clay region, the road to be of small cost and sufficient for a small amount of traffic in heavy wagons.

Boilers and Engines.

1. Give the ordinary commercial rules for rating the horse-power of boilers.

What quantity of steam is required per horse-power per hour in the best quality of condensing engines of about 500 HP.?

2. Would a chimney 60 ft. high, having a flue 4 ft. in diameter, be equally good for anthracite and bituminous burning furnaces? If not, why not?

Give the essential features to be considered in the design of a furnace for the burning of anthracite coal and of one for a bituminous coal having a large percentage of volatile hydrocarbons.

3. Sketch the following different kinds of boilers: Return tubular, vertical fire tubular, water tubular, Scotch, locomotive.

State the advantages and disadvantages of each, describing, among other things, wrought iron, cast iron, cast steel, flowed steel and wrought steel, corrugated flues, straight tubes and curved tubes.

4. What elements should be included in the specification for an efficient 500-HP. cross-compound condensing engine direct-connected to two electric generators used for electric-light service?

5. Make diagrams of and describe jet and surface condensers, give the advantages and disadvantages of each, state the auxiliary machinery required in connection with condensers, and state what you know of central condensers for a plant of several engines.

Structures.

1. Design a machine shop 300 ft. long and 90 ft. wide, walls 30 ft. high, benches and belted tools to be placed on the sides of the shop, the central bay to be a single story served by a traveling crane and having a railroad track and floor for heavy, movable tools. Materials are to be steel, brick, wood, concrete and slate. Foundations supposed to be in a soil which will sustain 1 000 lb. per sq. ft. at a depth of 1 ft. and 2 000 lb. at a depth of 10 ft., water met at a depth of 5 ft. Weight of 250 lb. per sq. ft. is to be provided for on the

second floor and 500 lb. per sq. ft. on the lower floor. Make free-hand sketches of plan, longitudinal and cross-sections.

2. Show full details of second floor using expanded metal or similar construction with fireproofed wood floor.

3. Show detail of floor in central bay to support work under construction and electrically-driven movable 15-ton tools.

4. Show details of a double sash, check-rail, box-frame window and the setting of the same in the side wall.

5. Show in detail and describe fully the construction of a tight skylight 6 ft. by 10 ft. in one side of the roof.

Masonry and Foundations.

1. Discuss pile foundations in mud, quicksand and clay. Give rules for the determination of the bearing power of piles driven by ordinary pile-driver and by steam-hammer. Under what conditions does each give best results? Why?

2. Under what conditions would you use screw piles and piles with disks? Describe the method you would use to put each kind in place. Design the screw end of an 8-in. steel pile to be placed in 30 ft. of water, seated in a sandy bottom, and to support 150 000 lb.

3. Given a machine shop on compressible soil, to supply a foundation for a 15-ton steam-hammer. Show how you would design the foundation without the use of wooden piles.

4. Give specification for laying best quality of stone masonry; also for a brick wall with ashlar front.

Show how terra-cotta caps and lintels should be laid and secured.

5. Give specification for Portland cement concrete to be used for a building foundation. Give specification for the plastering of a room with regular three-coat work.

Dry-dock.

The site for a dry-dock having been selected and test piles driven, it is found from the latter that the penetration of the piles in the bottom of the dock will be about 40 ft. in sticky mud, the penetration under the last blow of a 3 000-lb. hammer falling 25 ft. being 1 in.

Sketch out, free-hand, a design for a concrete dry-dock with granite protective trimmings for all necessary points, the dock to be 600 ft. long on the floor from the gate-sill to first altar at head of dock, with a width sufficient for a battleship of 72 ft. 6 in. beam. It is desirable to use due economy in the design, and to make the fullest

use possible of the piles in conformity with good practice. A caisson gate will be used, but no details of it will be required.

Materials of Construction.

1. Describe fully the manufacture and characteristics of high-grade building brick, Roman brick, sewer brick and terra-cotta tile.

2. Describe the difference between Rosendale and Portland concretes. Give the conditions under which you would use each kind.

What is the method you would employ to find the best proportions to be used in a concrete composed of broken stone, gravel, sand and cement?

3. In the case of a granite inverted arch resting on a heavy concrete bed in the bottom of a dry-dock, state how you would cut and bed each block.

Give a specification for high-grade roofing slate.

4. Describe by diagram the method of cutting quartered oak from logs; also edge grain flooring.

Give merchantable inspection for yellow-pine boards and dimension lumber.

5. Describe the characteristics and give some of the principal uses for long-leaf yellow pine, loblolly, spruce, white pine, white oak, cypress.

6. Describe briefly the manufacture and characteristics of acid open-hearth steel, basic open-hearth steel, Bessemer steel and cast iron.

7. Describe in detail the manufacture by the open-hearth process of a modern structural shape, beginning with the taking of the ore from the mine.

8. Describe lead and zinc paints. Give the proper methods and proportions of mixing the manufactured article with oil and dryers for inside and for outside work.

9. Describe the best paints and other materials for use in protecting steel exposed to air and gases in a machine shop, in a water tower and trestle, and in a steel pier in a tideway.

10. Discuss slate, tin and copper for use as a roof covering. Describe the methods to be used in laying each kind. Give a specification for good roofing tin.

Railroads.

1. What is the degree of curvature of a railroad track? Show how a curve can be staked out by the method of tangents. Describe

in detail the usual method of staking out 475 ft. of a 4° curve, starting at station 625-50, using a transit and a 100-ft. tape.

2. Describe in detail the method and work necessary to lay a side-track from a main line already in place. Draw diagrams of plans and cross-sections of the parts.

3. How short a radius can be safely used in yard tracks of 4.7 ft. gage? What limits the radius in this case? What is the best radius to use in industrial tracks of about 21 in. gage as usually built in this country?

4. Make cross-sections of T and girder rails and discuss their advantages in street track work.

5. Indicate in detail the rolling-stock necessary for a large navy yard, to include all necessities for the transportation of materials, for making general and special repairs, and for convenience and economy in all work which may be brought within reach of the track system.

Wharf.

Design a timber-pile pier 80 ft. wide, 600 ft. long, for the dockage on both sides of ocean steamships. Depth of water at mean low water, 27 ft.; mean rise of tide, 4 ft.; bottom material, river mud to depth of 80 ft. Sketch details and main cross-sections of wharf, ready for commercial use. Give necessary formulæ used in the design.

Quay Wall.

Design a quay wall to be built under the following conditions:

Mean rise and fall of tide, 5 ft.; extreme rise and fall, 9 ft.; bottom slope, about 1 to 8, running out to a depth of 32 ft. at extreme low water; character of bottom, 2 ft. of mud over sand and indurated gravel, into which wooden piles can be driven by impact less than 8 ft.; the water alongside the wharf to be at least 25 ft. deep at mean low water, and 30 ft. at mean low water 15 ft. from the face of the wall; coping of the wall to be 5 ft. above mean high water.

The wall is to be of a permanent character, located in a semi-tropical climate, where the teredo is very active. The design is to include bollards.

Water Supply.

A town of 40 solidly built blocks, each block being 200 ft. wide and 400 ft. long and containing 32 4-story dwellings, is to be fur-

nished with water from four non-flowing bored wells located outside of and one-quarter mile from one end of the town.

The town is located in a flat country, and is laid out in a rectangle four blocks wide and ten blocks long, with streets 60 ft. wide.

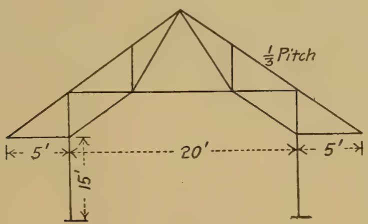
Design and lay out a complete water system from the wells to fire-plugs and house connections.

Sewer System.

A tidal river flows beside one of the long sides of a town. The surface of the land is 2 ft. above extreme high water and 5 ft. above mean low water, the mean range of tide being 18 in. Design a separate system of sewers for the above-described town and include house connections.

Strains in Structures.

The accompanying sketch shows the outline of columns and roof trusses of a steel-frame mill building 47 ft. long, to be erected in Washington, D. C. It is to have double doors in the ends, single doors and box-frame windows in the sides; its roof and sides to be covered with No. 22 corrugated galvanized steel. The columns are to be bolted down to concrete pedestals in the ordinary way, and are continuous from ground to top chord of trusses.



Determine the frame for a proper dead load and snow load combined, and for a wind load of 30 lb. per sq. ft. against a vertical plane, paying special attention to knee braces and columns. Show the purlins, side framing, etc., and show main details. Solve graphically and find stresses at one section analytically.

Crane.

An electric traveling crane is to be installed in a new shop (not yet built), of which the span between outside flanges of columns is 50 ft. The capacity of the crane is to be 30 tons. Sketch out the arrangement of the crane as regards general details as to its con-

struction and the design of the building as affected by the installation of the crane.

Briefly outline the calculations necessary to the design of the crane girders, defining the position of the load for the various maximum stresses.

CHIMNEY.

Using free-hand sketches, design a round brick chimney for a plant of 1 200 HP. on a good clay stratum.

Determine the center of pressure and direction of the resultant of forces, using a horizontal wind-pressure of 30 lb. per sq. ft. and the usual weight per cubic foot for brick masonry.

ELECTRIC MACHINERY.

1. Give a diagram of a six-pole compound-wound, direct-current electric generator.

2. Give switchboard instruments and connections for two generators and six feeder circuits.

3. Describe the wiring of a three-wire system to use 110-volt lamps and 220-volt motors.

4. Describe open and enclosed arc lamps; state which is more economical and give the reasons.

5. In ordinary machine-shop practice, where there are traveling cranes, would you use direct-current or alternating-current machines? Why? What are the principal conditions for best use of alternating-current power plants?

EXAMINATION QUESTIONS FOR CANDIDATES FOR THE POSITION OF CIVIL ENGINEER, U. S. NAVY.*

The grade of Civil Engineer in the United States Navy is now full, and vacancies which may occur in the future will be filled by promotion from the grade of Assistant Civil Engineer. At present there are no vacancies in the grade of Assistant Civil Engineer. The last Congress, however, passed a law authorizing the appointment of three Assistant Civil Engineers each year until the full number of twelve is reached. Under the provision of this law, there will be three vacancies in the grade on Jan. 1, 1904. An examination will probably take place next November or December, for the purpose of receiving eligibles for appointment immediately after Jan. 1, 1904. A vacancy in the corps will occur as the result of retirement in March, 1904, and should a sufficient number of candidates pass the examination in November or December, it is probable that this vacancy will be filled by appointment from that list of eligibles. As it is likely that some of our readers may wish to take this examination, we have secured from Admiral Mordecai T. Endicott, Chief of Bureau of Yards and Docks, Navy Department, and publish herewith the questions submitted to candidates at the last examination. These same questions will not, of course, be asked in the coming examination, but they may prove helpful to prospective candidates as a general index of the character of the examination to which they will be subjected.

To repeat information which we have already given, Assistant Civil Engineers will enter the corps with the pay of $1 800 per annum, which at the end of five years will be increased to $2 100. Assistant Civil Engineers, as well as Civil Engineers, are regularly commissioned officers in the U. S. Navy, subject to all the provisions of law relating to such officers, namely: retirement on three-quarters pay upon arriving at the age of 62, or if disabled in the line of duty; pension to family in the case of death in the line of duty, etc. It may also be noted that candidates who think of taking the coming examination should have the question of their health and physical soundness definitely determined by a reputable physician before subjecting themselves to the time and expense incident to appearance before the examining board. The medical examination required by the orders of the department is rigorous, and in the last examination numbers of young men were disqualified by the Medical Board. The questions asked at the last examination were as follows:

English Grammar and Composition.

1. The papers of the candidates will be marked for this question.

2. State in not less than 500 words whether in your opinion it

* From *Engineering News*, August 13, 1903.

should or should not be the policy of the United States to increase the number of its foreign naval stations and why.

3. Correct, in the body of the sentence the following, where necessary.

(*a*) Though John, George and myself were there, the sentiment of the meeting were so strongly in opposition against our ideas that we could do nothing for our cause.

(*b*) The formula for these circulations are so intricate as to render the results extremely liable to inaccuracies.

(*c*) The indices of these books are objected to on the ground that their inaccuracy and incompleteness renders them almost wholly useless.

(*d*) Even when given work that they should be used to, neither the blacksmith or his helper were able to show their ability.

(*e*) They, who so often rail at fortune, are the very ones, who, given the opportunity, never betters their condition.

(*f*) It has occurred to Henry and myself that, though the data is not complete, we could get the result by interpolation.

(*g*) It is they who make the most mistakes who consider themselves nearest perfection.

(*h*) I wish I was able to go but I will not have the time to.

(*i*) Should either John or I be invited we will have to go.

(*j*) Gents will be allowed to smoke on the four rear seats only.

4. Define the following: Metonymy, allegory, metaphor, dactyl, tautology. Illustrate by examples.

5. Give the present indicative, present infinitive, past indicative and perfect participle of the following: Were, lost, loosen, bat, bit, bid, crow, went, lean, slink.

Arithmetic.

1. It is desired to use the same panel length in the construction of three buildings whose dimensions are to be as follows: 283 ft. 9 in. by 50 ft., 132 ft. 5 in. by 50 ft., and 189 ft. 2 in. by 50 ft. What is the greatest length that can be adopted?

2. If eight excavators dig a ditch 4 ft. wide, 10 ft. deep and 200 yds. long in 50 days of 10 hours each, how many nights of 7 hours each will four excavators require to dig a ditch 3 ft. wide, 8 ft. deep and 500 ft. long, assuming the difficulty of working at night to be one-seventh greater than by day and the hardness of the ground in the smaller ditch to that in the larger ditch as 6 is to 5?

3. The market quotation for Hemlock, Yellow Pine, White Pine, and Oak are \$20, \$30, \$72 and \$80 per M., respectively. The total cost of a certain job is \$7 200, of which 60% is for lumber. Of the total cost of the lumber, 18% is oak, 12 by 14 in.; 28% is white pine,

1 by 4 in.; 34% is yellow pine, 6 by 10 in., and the remainder hemlock, $2\frac{1}{2}$ by 8 in. Find the number of lineal feet of each.

4. Find the sixth root of 2749.865307480007 to three decimal places.

5. A contractor buys cement at 43 cts. per bag, sand at 52 cts. per cu. yd., and broken stone at \$1.10 per cu. yd. If the bulk of 7 bags of cement is 8 cu. ft. and the voids in the sand and stone are 35% and 42% of their respective bulks, find the value of the material used in making 67 cu. yds. of concrete of $1:2\frac{1}{2}:5$ mixture, allowing 5% for waste.

Geometry.

1. What is the measure of the angles formed by two chords intersecting within the circumference of a circle? Prove the proposition.

2. What is the area in square feet of a quadrilateral circumscribed about a circle whose radius is 48 ft., if the perimeter of the quadrilateral is 400 ft.?

3. The volume of a certain cone of revolution is 1 200 cu. in. and its altitude is $26\frac{2}{3}$ in. What is the volume of the rectangular prism whose base is circumscribed about the base of the cone and whose altitude is that of the cone?

4. A regular hexagonal pyramid is circumscribed about a circular base, the perimeter of the circle being 117.8 in. If the slant height of the pyramid is equal to the diameter of the circle, what is the lateral area of the pyramid?

5. The apothem of a regular pentagon is 34.6 and a side is 50; find the perimeter and area of a regular pentagon, the apothem of which is 8.

Algebra.

1. Multiply $a^{\frac{3}{2}}b^{-\frac{1}{2}} + 2a^{\frac{1}{3}} - 3b^{\frac{1}{2}}$

by

$$2b^{-\frac{1}{2}} - 4a^{-\frac{1}{3}} - 6a^{-\frac{2}{3}}b^{\frac{1}{2}}$$

2. Solve $\sqrt{3x+1} = \sqrt{9x+4} - \sqrt{2x-1}$.

3. Expand $\sqrt[3]{1-2x-2x^2}$.

4. A and B run a mile race. In the first heat A gives B a start of 11 yards and beats him by 57 seconds; in the second heat A gives B a start of 81 seconds and is beaten by 88 yards. In what time can each run a mile?

5. A gives to B and C as much as each of them has; B gives to A and C as much as each of them has; and C gives to A and B as much as each of them has; in the end each of them has \$6. How much had each at first?

TRIGONOMETRY.

1. Prove that $\sin 3x = 3 \sin x - 4 \sin^3 x$.

2. Derive the trigonometrical functions of 30°. Give the values of the functions of 0°, 90°, 180°, 270°.

3. Prove that $\tan x + \cot x = \frac{2}{\sin 2x}$.

4. In any oblique triangle state and prove the relation of the sides and a function of the angles opposite and show how this is used to derive a formula for the solution of triangles in which a side and the adjacent angles are given.

5. Given two sides and the included angle, derive a formula for use in obtaining the area of any oblique triangle. The angles being A, B, C, and the sides opposite a, b, c, find the area when $b = 20.25$, $c = 30.27$ and $A = 30°$.

ANALYTICAL GEOMETRY.

1. Given the general equation of the line

$$Ax + By + C = 0$$

what are the values of the following:

(a) The intercept on the axis of x.
(b) The intercept on the axis of y.
(c) The normal distance of the line from the origin.
(d) The tangent of the angle the line makes with the axis of x.
(e) If A, B, and C are all positive, in which quadrant does the normal lie?
(f) What relation must exist between the constants for the normal to lie in the first quadrant?
(g) If B and C are positive and A negative, in what quadrant does the normal lie?

2. Find the equation of the circle whose center is at the origin of co-ordinates, and which is tangent to the line $3y - 9x = 11$.

3. What is the equation of the chord of the circle $x^2 + y^2 = 136$ which passes through $-2, -7$, and is bisected at this point?

4. For what point of the parabola $y^2 = 18x$ is the ordinate equal to three times the abscissa?

5. Find the length of the line

$$\sqrt{3}\, y + x - 14 \sqrt{3} = 0$$

intercepted by the co-ordinate axes. What angle does the line make with the axis of X?

Calculus.

1. Find the first derivative of y with respect to x of

$$(a)\ y = \log (3x^2 + x)$$
$$(b)\ y = x^n a^x$$
$$(c)\ y = \sin^3 x \cos x$$
$$(d)\ y = \frac{\tan x - \tan^3 x}{\sec^4 x}$$
$$(e)\ y = \tan - \frac{x + a}{1 - a x}.$$

2. Find a quantity x, such that it shall exceed its cube by the greatest possible value.

3. Integrate:

$$\int_0^a \int_x^{2x} \int_0^{x y} x^2 yz\, dx\, dy\, z.$$

4. A rectangular box, open at the top, with a square base, is to be constructed to contain 300 cu. in., what must be its dimensions to require the least material?

5. Find the area included between the curve $a^2y = x^3 + ax^2$ and the axis of x, between the limits $x = - a$, and the origin.

Surveying and Instruments.

1. Describe in detail the work of measuring an accurate base line for a topographical survey covering 500 square miles. What instruments are required?

2. State how you would organize, and the instruments with which you would equip, a party for running a preliminary survey for the location of a railroad line. Describe in detail the process of making the survey, and the operations involved.

3. Describe three methods of making a contour survey and explain when each would be used.

4. Name in proper order the principal adjustments of the transit and describe how they are made.

5. Sketch a longitudinal section through a Y-level, showing the principal parts, including the position and shape of the lenses.

6. Give field adjustments for a Y-level. How would you use a level which is out of adjustment to get accurate elevations?

7. A tidal river, main channel 400 ft. wide, is to be dredged to a depth of 32 ft. at mean low water. It is proposed to pay for the work on the basis of place measurement. The exact location of the plane of mean low water is not yet known. A low sandy beach is parallel to channel. Describe how you would make all the necessary observations, and how you would make hydrographic survey where soundings and estimates must be made quickly and often. State method of making soundings, equipment needed, precautions necessary to secure accurate work, and number and position of men required. State what method you would use to determine whether any small, isolated rocks remain in channel on completion of work.

8. On the sketch below (Fig. 1), the heavy line indicates the axial location of a ship canal which is to be 300 ft. wide on the bottom, side slopes 3 to 1, depth of water 30 ft., 20-ft. berms on each side 6 ft. above the water. Plot on the sketch the plan of the completed cut, give a cross-section at *A*, *B* and *C* and figure the volume of excavation between *A* and *C*.

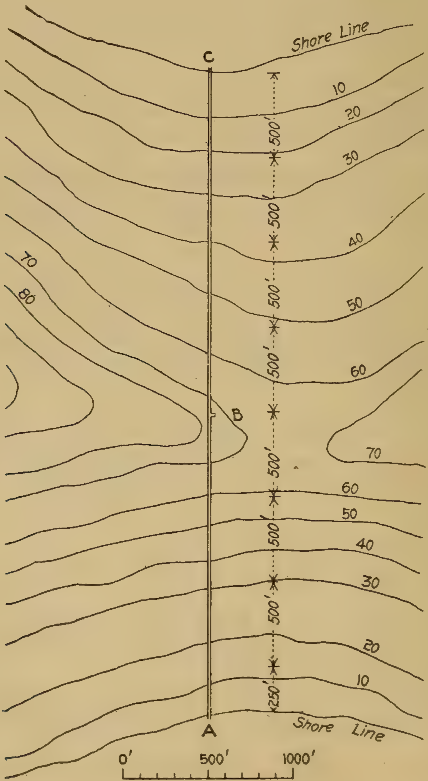


FIG. 1.

9. (*a*) It is decided to establish a naval station in Great Harbor, Culebra (see chart).

Indicate thus *A* on the chart, the location of primary triangulation stations for a survey of the harbor and adjacent region and connect them. Locate a suitable base and connect with the triangulation.

(*b*) State how you would obtain complete tidal data concerning the port.

(*c*) Make perspective sketch of harbor entrance and south shore of island from point marked *A*.

(*d*) Make a paper location of a railroad from San Ildefonso to Ensenada Fulladora.

(*e*) Plot the dangers to navigation given on the following sheet.

[(281) WEST INDIES—CULEBRA ISLAND—GREAT HARBOR—ROCK REPORTED.—Lieutenant C. M. Fahs, U. S. Navy, navigator of the U. S. S. "Olympia," reports the existence of a rock, with 18 ft. of water over it, outside of the Great Harbor, Culebra Island, which was discovered while surveying. The rock is located 1 270 yd. S. 12° 45′ W. true (S. by W. ¼ W. Mag.) from the house on the south beach of Punta Carenero, shown on U. S. Coast Survey chart No. 913.

(2025) PORTO RICO—CULEBRA ISLAND—GREAT HARBOR APPROACH—GROUPER SHOAL—ROCK TO WESTWARD.—Information has been received from Lieutenant C. M. Fahs, of the U. S. S. "Olympia," that while surveying he found a coral head or rock, some 6 ft. sq., with only 13 ft. of water over it. Its position as taken from the small house on the south beach of Punta Carenero, is S. 3° W. true (S. ⅜ W. Mag.), distance 1 060 m. (1 159 yd.).

The rock lies right in the western channel leading along the reef toward Great Harbor. A buoy, No. 2½, has been placed about 10 ft. to the westward of the rock in 7½ fathoms of water to mark its position.]

PHYSICS.

1. Show by diagram the principle of the ordinary sextant.

2. Show how the position of metacenter affects the stability of a floating body.

3. What weight placed 2 ft. from the axis of a wheel will balance a weight of 18 lb. placed 4 in. from the axis, while the wheel is revolving?

4. Give three methods for the transmission of heat and illustrate by examples.

5. Define specific gravity. Describe method of obtaining the specific gravity of Portland cement, and state what specific gravity you would expect to obtain.

6. Explain the principle of the screw jack and illustrate by diagram the actual power required at the end of a 30-in. lever, to lift a weight of 10 tons, the pitch of the screw being five turns per inch. The diameter of the screw is $3\frac{1}{2}$ in.

7. In what proportion must water at a temperature of 30° and linseed oil (specific heat 0.5) at a temperature of 50° be mixed so that there are 20 kilograms of the mixture at 40°?

8. What is the relation between the graduations on the three standard thermometers?

9. The diameter of a steam engine cylinder is 9 in.; the length of crank, 9 in.; the number of revolutions per minute, 110; the mean effective pressure of the steam, 35 lb. per sq. in. Find the indicated horse-power.

10. Two bodies are let fall from the same point at an interval of two seconds. Find the distance between them after the first has fallen for six seconds.

Geology.

1. Name the principal rocks, describe their formation and composition. What is the primary division of rocks?

2. What are anticlines; synclines; faults? What are the dip and strike of strata? What are unconformable strata? What is meant by metamorphic rocks and what are the principal ones? What their composition? What is the most common sedimentary rock and what is its composition?

3. What is a glacier? Describe general characteristics and name three well-known ones.

4. What is an iceberg and how formed? Upon what does the erosive power of a stream depend? Explain what ratio governs its transporting power. y6

5. Outline in briefest form present theories as to seismic and volcanic action.

Engineering Construction.

1. Make a detail drawing of the roof truss and columns shown in Fig. 2.

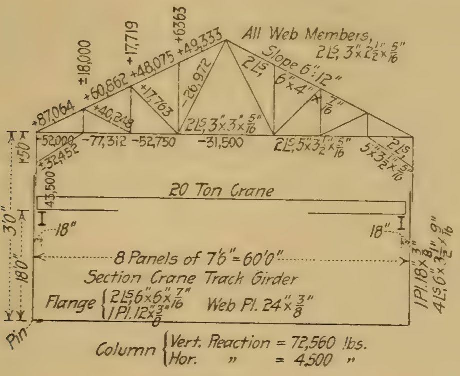


FIG. 2.

Allow 10 000 lb. per sq. in. shearing value on rivets.
" 20 000 " " " " bearing value on rivets.
" 250 " " " " pressure on bed plates.

The maximum size of members which can be shipped is 11 ft. wide by 35 ft. long. Purlins to be 10 in., 15-lb. channels at each panel point.

2. Make sketches showing construction of a concrete-steel floor and describe briefly the materials and construction.

(1.) For a warehouse, floor beams to be 6 ft. on centers, load 500 lb. per sq. ft.
(2.) For an office, floor beams as in (1), load 100 lb. per sq. ft., to have a wooden wearing surface and suspended ceiling beneath.
(3.) For a toilet room, floor resting directly on the ground.

Make sketches of a terra-cotta floor end construction.

3. Make sections showing the construction of a double-hung window in an office building with brick walls. Name all parts. Show construction of a 4-in. terra-cotta partition plastered both sides. Of a 2-in. solid-plaster partition and door frame. What is the maximum height for which the above partitions should be used?

Masonry and Foundations.

1. Give the different kinds and qualities of brick used for ordinary building construction. State for what class of structures each is used and the method of laying each to secure the best results.

What precautions should be observed in laying brickwork in this vicinity as regards conditions of weather? When may lime mortar be used and when never used?

2. Give the usual methods employed to determine the bearing power of soils, making detailed sketches where necessary.

3. Using an ordinary drop hammer weighing 3 000 lb., the leads being 60 ft. in length, state what formula you would use to determine the bearing power of piles, discuss the formula, and discuss also the process of driving piles, stating which methods to employ and which to avoid in order to secure the best results, paying special attention to height of fall.

4. A column of a certain tall building supports 360 tons total load. The material of the building site will support $1\frac{1}{2}$ tons per sq. ft. safely, and piles cannot be used. Design a foundation in steel and concrete, with pedestal, for Z-bar column of 4 Zs 6 by $\frac{3}{4}$, 1 pl. 8 by $\frac{3}{4}$, and 2 pls. 14 by $\frac{3}{4}$. The foundation is limited in length to 20 ft.

$I = 795$ for 18-in. I-beam.
$I = 609$ " 15 " "
$I = 268$ " 12 " "
$I = 122$ " 10 " "
$I = 57$ " 8 " "

5. A masonry pier supporting a highway bridge is to be located in a stream at a point where the depth of water is 11 ft. at normal stage. The bottom is mud with hard clay at a depth of 40 ft. The roadway is 35 ft. above normal stage of water and the greatest recorded flood stage is 15 ft. Make sketch showing pier and foundation, also sketches of such auxiliary construction as may be employed. Dimensions required.

MECHANICS.

1. A column supports two crane girders 20 ft. and 24 ft. long respectively (Fig. 3). The rolling loads on these girders are as follows and always have the same relative order with respect to the spans. Find the maximum load on the column and the maximum shear at the end and centre of the 24-ft. span.

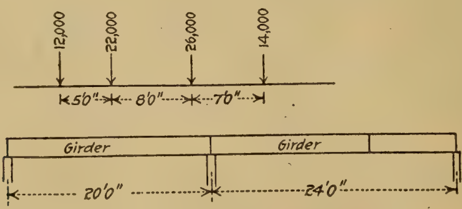


FIG. 3.

2. A beam inclined to the horizontal at an angle of 30° and carrying a uniform load of two tons per horizontal foot rests against a vertical wall at its upper end and is anchored to a pier at its lower end; the distance from face of wall to center of pier is 25 ft. If the pier is 10 ft. high and of square section, what must be its size to insure stability, the weight of masonry being 150 lb. per cu. ft.?

3. A certain arch is 2 ft. 6 in. deep at the keystone and has a rise of 5 ft. and a clear span of 60 ft. If the total uniform load, including the dead weight, is 2 000 lb. per sq. ft., find the pressure per square inch at the center, the reactions at the abutments and show the method of obtaining the line of pressures.

4. A column 32 ft. high is securely anchored at the base and loaded with 150 000 lb. on top and 60 000 lb. 24 ft. above the base and 18 in. from the center line of the column in the plane of the web. If the column is an I-section, composed of a web plate 16 by $\frac{1}{2}$ in., and four angles 6 by $3\frac{1}{2}$ by $\frac{1}{2}$ in., with the 6-in. leg at right angles to the web, what is the maximum fiber stress in the column?

5. The top-chord panel of a roof truss, composed of two 6 by $3\frac{1}{2}$ by $\frac{1}{2}$-in. angles of 5-ft. clear span, has a direct compressive stress of 98 000 lb. and supports a uniform beam load of 600 lb. per ft. of span. What is the combined stress per square inch? The I of the section is 33.2.

6. A cone of revolution whose base is 10 in. diameter and altitude 15 in. is immersed, vertex down and base parallel to the surface of water. The base is 10 ft. below the surface. Find the pressure on the conical surface and the tendency of the body to rise to the surface.

7. A concrete well is built in a reservoir. The height of the wall is 35 ft., the elevation of the outside water 30 ft., and the interior is pumped out to a depth of 8 ft. from the bottom. If the wall is 18 in. thick, what is the pressure per square inch in the body of the wall at a depth of 30 ft. from its top? Diameter of well = 40 ft.

8. The weight of bituminous coal being 50 lb. per cu. ft. and its angle of repose 45°, design a wall to retain coal 18 ft. high, flush with its top. What modification must be made if the coal is piled at its natural slope, its toe being at the top of the wall?

9. Define the following:

Moment of inertia,
Center of percussion,
Radius of gyration,
Elastic limit,
Modulus of elasticity,
Resilience,
Factor of safety.

10. What weight "W" is necessary to balance the load of 5 000 lb. (Fig. 4)?

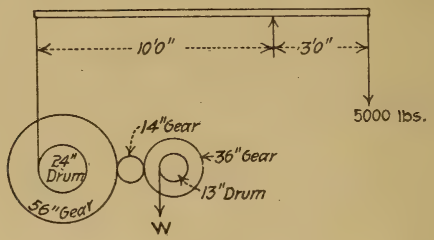


FIG. 4.

STRESSES IN STRUCTURES.

1. A train-shed roof is supported by trusses spaced 20 ft. on centers on an outline shown on accompanying sheet. The total load on the roof is 60 lb. per sq. ft. Find the stresses in the truss graphically and proportion the members. What unit stresses would you allow? Make a sketch showing arrangement and size of lateral bracing you would use for first four panels from outer end of shed. Show stresses on left half and sizes on right half of diagram (Fig. 5).

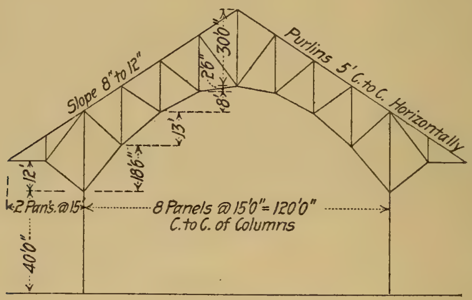


FIG. 5.

2. Find stresses in frame (Fig. 6) analytically.

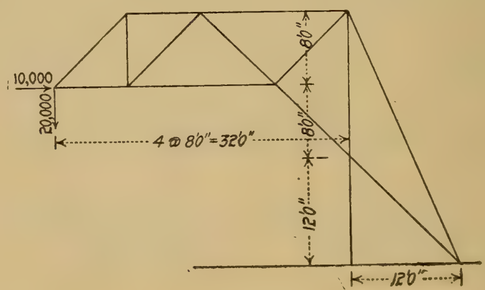


FIG. 6.

3. Determine stresses in frame shown above (Fig. 7) for loading given. The column is a stiff member from the pin at the ground level to the bottom chord of the roof truss.

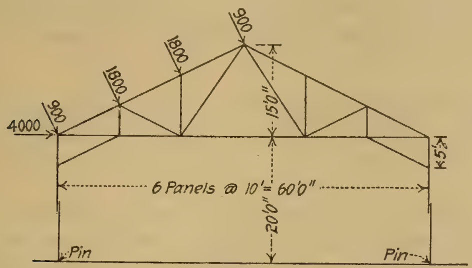


FIG. 7.

PAVEMENTS.

1. Specify all the materials and the finish of a granolithic side-walk.

2. Sketch cross-section and describe materials and construction of a street 91 ft. between lines, laid out as follows: Double-track street railway in centre, 4 ft. 8 in. gage, 10 ft. 4 in. centers, paved with granite blocks; on each side of a track a roadway 18 ft. wide, paved with asphalt; gutters, 2 ft. wide each, of vitrified brick; granite curbs; cement sidewalks, 8 ft. wide; parking, 10 ft. wide. Indicate on the sketch the various sub-constructions in the street and their connections.

3. What crown would you give to street paving? What minimum grade of gutters? What do you consider to be the limiting grades for asphalt paving, vitrified brick, granite block, macadam? Why?

MATERIALS OF CONSTRUCTION.

1. Write a specification for good building sand and for gravel for foundation concrete. What should be the size of sand particles to make the strongest mortar?

2. Write a specification for paving brick; describe tests that should be made on same.

3. Why is open-hearth steel preferred to Bessemer for structural material? With open-hearth steel, would you prefer basic or acid for structural material? Why?

4. What is Rosendale cement? Describe its manufacture. What do you understand by Portland cement? Describe its manufacture.

5. Write a specification for lime to be used in the construction of a brick building. Specify the mixing of mortar for the above.

6. What is the composition of commercial roofing plates of so-called tin? How are they made? How is the thickness of copper for roofing purposes specified? What are its advantages over tin or galvanized iron?

7. Discuss rusting of steel and methods of preventing by painting. What paint would you use on sheet-steel roofs? On corrugated steel sides? On steel framework of buildings? Why?

8. What kind, grade, and quality of wood would you specify for a timber wharf, above the tops of the piles? For a railroad trestle? For railroad ties? For the floor of a shop? For the floor of an office? For a shingle roof? For the frames and siding of a wooden building? For the doors and windows of a dwelling?

9. A circular pump well 30 ft. in diameter, with concrete bottom and sidewalls about 4 ft. thick, is to be made waterproof against a maximum head of water of 30 ft. Design and specify material and workmanship for waterproofing.

10. Name the various kinds of glass manufactured and state the purposes for which generally used.

Water-Works.

1. A 12-in. pipe on a grade of 3 ft. per thousand is flowing half full. Assume a coefficient of friction, and find the discharge of the pipe per second.

2. Write an outline specification for the laying of 16-in. cast-iron water main in this vicinity to carry a working pressure of 125 lb. Describe briefly the most important features to be looked after to secure the best results. Part of the main is laid in rock and part in very soft, wet ground. The thickness of the above pipe is $\frac{3}{4}$ in. What is the stress per square inch in the metal?

3. A town of 40 000 inhabitants is to be supplied with water for domestic consumption at an average rate of 60 gal. per capita per diem. The water is furnished from a reservoir through a cast-iron pipe line 2 miles long to a center of distribution in the town. Give the size of pipe necessary. The water level in reservoir is 200 ft. above center of distribution and located on comparatively level ground. Sketch a section and give area of a square reservoir with concrete core wall and earth embankments to contain a 30 days' supply. Location of reservoir is in good sand and clay, mixed.

Railways.

1. What are the relations between frog number, throw, lead, gage, radius of curvature, etc., of a turn-out? Describe each, and give formula. What is the minimum radius of curvature you would use for Navy Yard work where standard-gage cars are to be shifted?

2. Sketch a section through a steam railroad track suitable for permanent construction in a street paved with vitrified brick or granite blocks.

3. Make a sketch plan of a set of crossing-frogs for standard-gage steam railroad tracks, the angle of the crossing being 60° and the traffic over the crossing being heavy and at considerable speed.

4. Make a sketch of a spring-rail frog, and of a solid-filled, bolted frog.

Sewers.

1. Design the sewers as shown on the accompanying sketch (Fig. 8), figuring the sizes, locating man-holes, catch-basins, etc. The river bank is at M. H. W. and the point *A* at 15 ft. above M. H. W. with uniform grade toward river. The sewer is of the separate type and the water consumption is to be figured at 100 gal. per capita, with 300 residents on each block. No provision for growth of city.

2. What data are required for the design of a combined system of sewers and how would you proceed to calculate the conduits?

Fig. 8.

Wharf.

1. A timber pier 300 ft. long and 60 ft. wide is to be built projecting into a tidal river with mud bottom, varying from mean low water at the shore to a depth of 18 ft. at M. L. W. at the outer end. After the construction is completed berths are to be dredged on both sides to a depth of 25 ft. at M. L. W. The height of the deck above M. L. W. is 14 ft. The test piles driven to determine the bearing power of the bottom showed a total penetration below M. L. W. of about 36 ft., bringing up with a penetration of 1 in. per blow of a 2 800-lb. ram falling 20 ft. Design the wharf, showing neat freehand sketches of the principal details. Make a complete bill of material and estimate the cost of all items to be purchased.

Boilers.

1. Design a battery of boilers of the return fire tubular type, to supply 500 HP. at a steam pressure of 100 lb. per sq. in. The grate-surface, area over the bridge-wall, flue area, and general dimensions of chimney, all to be fully shown.

2. What is the rate of coal consumption per horse-power for the boilers of problem 1? How much water is evaporated per pound of coal? What is the ratio of heating-surface to grate-surface? How much heating surface is required per horse-power?

3. Give full details of a complete boiler test to determine efficiency.

4. Describe briefly the several types of condensers in use.

GENERAL APPENDIX II.

CIVIL SERVICE OF THE STATE OF NEW YORK.

GENERAL INFORMATION.*

Persons Who Will Not Be Examined.

No person is eligible to a competitive examination—(*a*) who is not a resident and citizen of New York State (except as indicated below), (*b*) who is not within the age limitations prescribed for the examination for which he applies, (*c*) who is physically disqualified for the service which he seeks, (*d*) who is addicted to the habitual use of intoxicating beverages to excess, (*e*) who has been dismissed from the public service for delinquency or misconduct within one year preceding the date of his application, (*f*) who has failed, after probation, to receive absolute appointment to the position for which he again applies, within one year from the date of the expiration of his probationary service, (*g*) who, within nine months has taken the same kind of examination for which he wishes again to apply, (*h*) who has made a false statement in his application or has been guilty of fraud or deceit in any manner connected with any application or examination under the Commission, or who has been guilty of crime or infamous or notoriously disgraceful conduct.

Non-residents or non-citizens may be admitted to examination for the following positions: Attendants, nurses and orderlies in asylums and hospitals and similar institutions; also for positions as scientists, technical and trade instructors and positions requiring special training and education, provided that if the eligible list resulting from any examination held for such a position contains the names of three or more persons who are citizens and residents of New York State, such persons shall be preferred in certification to non-residents.

Preliminary Requirements as to Education, Experience, etc.

No application for examination will be accepted unless the applicant satisfies all the preliminary requirements as indicated in the description of the particular examination. For professional positions candidates will be required to have the licenses required by law for practice of their respective professions in the State of New York. For positions in the Regents' office candidates must be graduates of a recognized high school or have an equivalent education,

* Extracts from Manual of Examinations of the New York State Civil Service Commission.

according to the standard of the Regents. For positions involving a knowledge of any trade candidates will be required to present evidence of having served the customary apprenticeship at such trade.

Where Examinations May Be Taken.

The Commission is required by law to hold examinations for all positions, except those the examinations for which "require special tools, machinery, appliances or laboratory facilities," in the following cities and towns:

Albany	Hornellsville	Newburg	Rochester
Amsterdam	Ithaca	New York	Syracuse
Auburn	Jamestown	Ogdensburg	Utica
Binghamton	Kingston	Olean	Watertown.
Buffalo	Lockport	Plattsburg	
Elmira	Malone	Poughkeepsie	

What Applicants Should Bring to Examination Room.

Persons taking the stenographer and typewriter examinations must provide themselves with typewriting machines and stands or tables; those taking the bookkeeper, draftsman, or other examinations requiring the use of instruments, must furnish the instruments required. Candidates for draftsman or tracer must bring drafting-boards suitable for paper 8½ by 14 in. All competitors must provide themselves with pens, penholders, pencils, erasers, ink and blotters. Competitors should not bring any paper for use in the examination room, as sufficient blank paper will be furnished for all purposes.

Each applicant *must present* his notice of examination in order to be admitted to the examination.

Change of Address.

Applicants and eligibles must keep the Commission informed of any change of post-office address. A failure to do so will be treated as the fault of the applicant or eligible, and may result in his losing an opportunity of examination or appointment. Requests to have the address changed should be made by letter, and should state whether the applicant has been examined or not. Such letter should relate only to the change in address.

Rules Governing Competitors in Examinations.

The following is a copy of the rules which are given to each competitor at the beginning of every examination:

1. You will find your examination number in the upper right hand corner of the declaration sheet which will be given you. *Write*

that number on each sheet of the examination. Fill out all blanks on question sheet before handing it in.

2. See that each sheet received by you pertains to the kind of examination which you are taking, and take care that you do not omit any of the sheets. Competitors are held responsible for errors and omissions.

3. Do not leave the room, if possible to avoid it, with a sheet before you unfinished, for if you do, the sheet will be taken up and will not be returned to you. Competitors are allowed to leave the examination room for luncheon on the completion of any sheet of questions after 12 o'clock. *No additional allowance of time* will be granted on account of such absence.

4. *Read carefully the printed instructions on each sheet before commencing work thereon.*

5. A question sheet spoiled by you cannot be exchanged for another of the same kind.

6. Perform all work on each examination sheet with ink.

7. Pencil and scratch paper furnished by the examiner may be used in preliminary work, except in spelling and verbal order exercises, which must be written with ink directly on the examination sheets from the dictation of the examiner.

8. Use no scratch paper except that furnished by the examiner, and, on completing an examination sheet, hand him the scratch paper pertaining to that sheet. Have all your work complete on the examination sheet however, as the scratch paper is collected, not for consideration in the marking, but for destruction.

9. No helps of any kind are allowed unless expressly stated to the contrary on the question sheet or in the instructions sent to candidates. Before the examination is commenced, hand to the examiner any written or printed matter that you may have which might, if used, aid you in your work.

10. *All conversation or communication between competitors during the examination is strictly prohibited.*

11. Do not copy or attempt to copy from the work of any competitor, or permit any competitor to copy from your work, or to read the examination sheets in your possession.

12. All necessary explanations will be made to the whole class. Examiners are forbidden to explain the meaning of any question

or to make any remarks or suggestions that may assist in its solution.

13. From one to three months may elapse before you are notified of your standing. No unnecessary delay will occur in marking your papers, and you are requested not to increase the labors of the Commission by making inquiries in regard to your standing, unless you have reason to believe that the notice to you has miscarried.

14. Copies of examination papers or examination questions must be handed in with the answers and *must not be taken from the room.*

[N. B.—A violation by you of the instructions contained in paragraphs 9, 10 and 11 will be deemed sufficient cause for canceling your papers. You are requested to report to the examiner any irregularity that may come under your notice during the examination.]

Method of Marking Examination Papers.

The following method is observed in marking examination papers by the examining division of the Commission:

After an examination is held, the papers are arranged by sheets or subjects and are forwarded under seal to the Commission. When they are reached in the order of marking, they are distributed by sheets to the examiners, Examiner A being given all of sheets 1, Examiner B all of sheets 2, Examiner C all of sheets 3, and so on. The work of each examiner is usually reviewed by another. When all of the papers of an examination have been marked, those of each competitor are then for the first time assembled or brought together, his general average is ascertained, his declaration envelope is opened, and the declaration sheet to which he has signed his name is attached to his examination papers. The identity of the competitor, therefore, is not disclosed *until his papers have been marked and reviewed and his general average determined.* The only exception is in marking experience and education, which is done upon the candidate's sworn statement and the answers received to letters of inquiry sent by the Commission to former employers and others acquainted with the competitor. As the charges for specific errors are fixed by the rules for marking, it will be seen that absolute impartiality, accuracy and uniformity are secured in the work.

Appeals from the markings are sometimes made by competitors, but the prospect of securing a higher average by such action is small. Errors on the part of examiners in making charges are seldom found.

The papers of all the competitors in an examination must be marked at the same time, and no competitor's papers will be made special or be marked in advance of others.

Rules for Marking Examination Papers.

In subjects for which specific rules of marking are not prescribed, the examiner will usually prepare a scheme of marking for each question, so as to be able to explain his marks in case they are questioned.

All examination papers shall be marked under the following rules:

Mark every correct answer.................................. 100

Mark every faulty answer according to its value on a scale of 100, or as specifically directed below, deduct the sum of the error marks of such answer from 100.

When the question requires in the answer a specified number of states, countries, persons, places, locations, or things, the quotient arising from the division of 100 by the number of states, countries, etc., required shall be the credit to be given for each state, country, etc., correctly named. If a greater number is given in the answer than is required, the additional number of states, countries, etc., shall be added to the number required by the question, and the quotient arising from the division of 100 by the number thus obtained shall be the credit to be given for each state, country, etc., correctly named.

Rules for Marking Arithmetic.

The examiner will prepare a scheme for marking each problem, giving proportional weights to the various steps or processes on the scale of 100. Charges for errors in computation in any step or process will not exceed the weight given such step or process.

No credit will be given for a wrong process.

For errors in work or operation, the following charges will be made:

	From 100 deduct—
1. For error in pointing off decimals in multiplication or division	25
2. For error in omitting decimal point or in pointing off decimals in addition or subtraction..............	10
3. For each evasion of a decimal or common fraction test in the solution of a problem......................	25
4. For each error in computation, provided that in solutions where the possible maximum number of chargeable errors in computation is less than 10, a proportionate charge shall be made for each error..	10
5. For error in copying figures from printed question or from work, wrong result being obtained...........	10
6. For error in copying figures from printed question or from work, right result being obtained...........	5

7. For indicating wrong process, but performing correct process.	5
8. For each improper use of the symbol or designation % or ¢ in connection with a decimal expression...	10
9. For each improper or incorrect designation of a partial or final result.	5
10. For failure to indicate the answer in problems by the letters "Ans.," or otherwise, when the answer is obscured by improper arrangement.	5
11. For each failure to use the sign $ or £, or any other monetary or commercial sign, or any sign by which the relations of quantities are expressed, when the use of such is required in the statement or solution of a problem.	5
12. For each error in denominate numbers in quantity of one denomination contained in a unit of a higher denomination	15
13. For fractions in answers not reduced to lowest terms..	5 to 10
14. For an approximate result not sufficiently exact.	5 to 10
15. If, when work or operation in full is required, the correct answer is given, but no work is shown.	40
16. If, when work or operation in full is required, the process is indicated, but no work or only part of the work is shown.	5 to 40
17. For superfluous or irrelevant work not canceled.	10
18. For giving proof instead of solution, according to gravity of error.	10 to 75
19. For complex statement, process or method, right result being produced.	10
20. If, when work or operation in full is required, an approximate answer is given, but no work is shown or indicated, charge 40 for omission of work and deduct from 60 a proportionate charge for number of figures incorrect.	

Rules for Marking Experience.

In marking experience the following topics will be considered:

Age.—The examiner will determine standard limits of age most desirable for the position in question. Candidates within those limits will receive the maximum allowance for age, and other candidates will be rated according to their variation from the standard adopted.

Height and weight will be considered for positions requiring physical strength or perfection, charges being made for defect in height from the standard adopted and for any great variation in weight from the recognized standard weight for the height and age of candidate.

Education will be considered for positions reasonably requiring educational attainments above the common-school grade, and will be rated according to its value in the opinion of the examiner.

Experience.—The rating for experience will be based on kind of work done, nature and length of employment, salary or compensation, extent of supervision over others, and other facts called for in application and experience blanks.

Letters of recommendation and certificates of character will be considered *only* when received in response to the inquiry or request of the Commission. Their effect on the rating of the candidate will depend on their contents and the extent to which they corroborate the candidate's own statements.

Every fact called for in the experience statement is important to the examiner, and candidates cannot be too careful to state in detail all important facts of their history.

Failure to satisfy any preliminary requirement of age, height, weight, education, or experience established for the examination in question will disqualify the candidate, and candidates who just satisfy the preliminary requirements will usually be given a minimum standing of 75 per cent.

Prospect of Appointment.

Except as indicated in this paragraph, it is not possible to estimate the prospects of an eligible for appointment, and attempts to predict when names might be reached for certification would be certain to result in disappointment. The law requires examinations to be held, but the passing of an examination does not insure either certification or appointment. The conditions of appointment in the various branches of the service are such that nothing can help and nothing can hinder the certification of a name in the order of its standing on a register. As the highest possible mark is 100 and the lowest that gives eligibility is 75, it follows that the nearer a mark is to 100 the more likely it is that the person may be reached for certification within the period of eligibility. There are usually on the registers more eligibles having ordinary qualifications than are required for appointment.

For the information of applicants the Commission mentions the following positions as those for which it has been unable to secure sufficient qualified eligibles: Apothecary; guard, Elmira Reformatory; physician; trained nurse; woman officer, state charitable institutions; stenographer, first and second grades, in state hospitals and institutions. Persons willing to accept such positions have excellent chance of appointment if successful in passing the examination.

Entrance to the service is usually in the lowest grades, the higher grades being filled generally by promotion. The prospect of promo-

tion varies so much in the different departments that no specific information on the subject can be given.

Promotion.

Under the civil service rules, vacancies in higher grades are filled as far as practicable by promotion from lower grades. Persons desiring promotion from chainman to rodman, rodman to leveler or engineering draftsman, leveler or draftsman to assistant engineer, tracer to chainman or junior bridge draftsman, junior bridge draftsman to bridge draftsman, bridge draftsman to bridge designer, should enter the regular, open, competitive examinations for the higher positions, provided they can satisfy the preliminary requirements. If successful in such examinations they will be certified for appointment in preference to persons not in the service. Special examinations are held as required for promotion from assistant engineer to first assistant engineer ($7 a day). The position of resident engineer will be filled by promotion (upon examination) from first assistant engineer or by open competition.

ENGINEERING STAFF OF THE STATE ENGINEER.

Exempt Positions.

3 Deputies	$4 000–$5 000	per annum.
3 Division Engineers	3 600	"

Competitive Positions.

16 Resident Engineers	2 400	per annum.
1 Chief Bridge Designer	3 300	"
1 Ass't Chief Bridge Designer	2 500	"
5 Bridge Designers	1 500–1 800	"
1 Mech. Engr. and Draftsman	1 500–1 800	"
6 Bridge Draftsmen	1 200–1 500	"
3 Junior Bridge Draftsmen	900–1 200	"
5 Tracers	600– 720	"
3 First Ass't Engineers	7.00	per day.
85 Assistant Engineers	5.00– 6.00	"
34 Levelers	4.50– 5.00	"
27 Rodmen	3.50– 4.00	"
36 Chainmen	2.50– 3.00	"
25 Civil Engineering Draftsmen	4.00– 5.00	"
6 Inspectors	4.00– 4.50	"
6 Foremen of Boring Parties	3.50– 4.00	"

DESCRIPTIONS AND SPECIMEN QUESTIONS OF COMPETITIVE EXAMINATIONS.

CONSULTING SANITARY ENGINEER.

State Department of Health.

$3,000.

The duties are the examination for approval of plans for water supply, sewer systems, disposal plants, etc., and other engineering work of the department. Candidates must have an experience of at least three years in sanitary engineering work, and no candidate will be accepted unless satisfactory experience of high grade is shown. Subjects of examination and relative weights: Sanitary engineering, 5; experience, 5. Time allowed, 8 hours.

Examination, May 12, 1906.

1 and 2. Write an essay on the most important sanitary work with which you have been connected, not less than three, nor more than five pages in length.

3. A city of 70 000 inhabitants is situated on a stream whose watershed is 200 square miles (above the city). One hundred miles distant, down stream, is another city, the water-supply of which is derived from the above stream. Discuss the methods of sewage treatment available for the city further up stream.

4. Discuss the theory and efficiency of filtration.

5. Discuss the methods by which preventable diseases are communicated and the methods used to combat them.

6. Discuss the legal aspects of the rights and responsibilities of a municipality in the use of a stream for water-supply and drainage.

7. State all the points that must be considered in the sanitary survey of a watershed.

8. Discuss the interpretation of analyses of a water-supply.

ASSISTANT ENGINEER.

$5 to $6 a day.

Candidates must have had at least three years' practical experience in civil engineering. Candidates who have graduated from a school maintaining a standard satisfactory to the Commission will be credited with one year of the required experience. Subjects of examination and relative weights: Theoretical and practical questions, including highway construction, strength of materials, canal and water-supply construction, hydraulics of canal and water-supply engineering, mechanics of engineering, specifications and estimates, topographic surveying and mapping, 10; experience and personal qualifications, 7; education, 3. Time allowed for the written examination, 8 hours. For part of the examination candidates will be permitted to use any books of reference they care to bring to the examination. The books must be left with the examiner in charge until such portion of the examination is reached.

(2 Sheets) Sheet No. 1.

STATE OF NEW YORK—STATE CIVIL SERVICE COMMISSION.

Examination for Assistant Civil Engineer.

Held at.................... Date......................
Time commenced..........
Time finished............. Examination No..........

Directions: Time allowed for the whole examination, 8 hours. Answer questions on blank paper provided, not on this sheet. Do not copy the question, but number the answers to correspond to the numbers of the questions. In the case of problems, all the work of solution must be given. Slide rules may be used to check results. Logarithm tables will be furnished by the examiners; no other books may be used in answering the questions of this sheet. Do not pass the tables to any other candidate, but return them to the examiner. Answer all of the following:

1. Give brief specifications for concrete to be put into a concrete arch, including proper mixing (by hand) and method of putting into place. In the field, how would you distinguish Portland from Rosendale cement?

2. Describe how you would build the foundation for the above arch if (*a*) upon marshy land, (*b*) upon shale with a dip of 45 degrees.

3. What are the most important requirements for which provisions must be made in the construction of a macadam highway? Why is macadam in such general use in preference to other kinds of road?

4. (*a*) How would you ordinarily decide whether a pile is sufficiently driven? (*b*) How would you prevent a pile from splitting at either end? (*c*) Suppose a pile were being driven into a river bottom and its penetration under a certain blow of the hammer ceased, what would you conclude if, under continued driving, the penetration was gradually resumed, and what would you do?

5. Suppose the earth behind a stone retaining wall to be liable at times to become very wet; describe the methods that might be employed to reduce the danger of damage to the wall. To what damage is the wall made liable by such condition?

6. Suppose it is desired to make a survey for an accurate contour map of a tract of nearly level marsh land containing several hundred acres, in order to determine the best means of draining it. Describe in detail your method of making such survey, including organization of party, etc.

7. A 24-in. sewer pipe is to be passed through a double-track railroad embankment for the purpose of draining the land on the upper side of the track. The top of the pipe is to be 4.5 ft. below the top of the track. Explain, using pencil sketches, how you would do this without interfering with traffic.

8. A wooden beam has to support a uniformly distributed load of 200 lb. per linear foot, including its own weight, and also a load of 2 000 lb. at the center. If the span is 18 ft. and the depth of the beam is 14 in., what should be its width for an extreme fiber stress of 900 lb.?

9. A segmental stone arch has a rise of 5 ft. and span of 40 ft. What will be the approximate horizontal thrust due to a load of 40 000 lb. at the center?

10. A derrick has a mast 30 ft. high; 5 ft. from its foot is fastened the boom 20 ft. long. The length of the tie from the end of the boom to the top of the mast is 15 ft. The mast is supported by two guy ropes fastened to its top; one of them is fastened 50 ft. from the foot of the mast and its horizontal projection makes 130°

with the horizontal projection of the boom; the other is fastened 40 ft. from the foot of the mast and its horizontal projection makes 90° with that of the first guy. Find the stresses in the guys due to a live load of 5 tons on the derrick.

(2 SHEETS) LAST SHEET.

STATE OF NEW YORK—STATE CIVIL SERVICE COMMISSION.

EXAMINATION FOR ASSISTANT CIVIL ENGINEER.

DIRECTIONS: Answer questions on blank paper provided, not on this sheet. In answering the questions on this sheet, any books of reference may be used. When such books are used for formulas, tables of constants, etc., candidates will give the name of the book and the page referred to. Give computations in full. Answer all of the following:

1. In order to find the amount of water flowing in a stream, a standard rectangular weir with sharp iron edges, having a crest 28 in. long is placed across the stream and the depth of the water is found to be 4.36 in. over the crest of the weir and the velocity of approach is found to be 0.25 ft. per second. The water from the weir is conducted down a planed board trough 36 in. wide, sloping 45° a distance of 40 ft. Find the cu. ft. of water per second flowing over this weir.

2. Find the horse-power developed at the foot of the trough in the above problem, making due allowance for the friction of the trough.

3. A canal feeder in firm gravel and earth free from weeds and rock has a bottom width of 5 ft. and sides sloping 45°; the longitudinal slope of the bottom is 1 in 1 000, and the depth of the water is 5.5 ft. Find the flow in cu. ft. per second. What depth of water will double the flow?

4. A stream having a surface width of 10 ft. flows through a small gorge in soft slate with sides arising from the banks of the stream and sloping 40° to the horizontal. The usual depth of the water is about 2 ft. Design a dam across this stream to give a center depth of 10 ft. and show that your design is stable against overturning.

5. Design the foundation for the above dam and give your calculations to determine the security of the dam against sliding or crushing of the foundation at the toe. The slate has a dip of 30° and a depth of 12 ft. overlying sandstone.

(2 Sheets) Sheet No. 1.

STATE OF NEW YORK—STATE CIVIL SERVICE COMMISSION.

Examination for Assistant Civil Engineer and Leveler.

(Note: Sheet No. 1 same for Ass't Engineer and Leveler, second sheets different.)

Directions: Time allowed for the whole written examination, 8 hours. Answer questions on blank paper provided, not on this sheet. Do not copy the questions, but number the answers to correspond to the number of the questions. In the case of problems, all the work of solution must be given. Slide rules may be used to check results. Logarithm tables will be furnished by the examiners; no other books may be used in answering the questions of this sheet. Do not pass the tables to any other candidate, but return them to the examiner. Answer all of the following:

1. Give in detail the best method of mixing Portland concrete "by hand." Give the reasons why Portland cement is generally preferred to natural cements.

2. Describe fully and in detail the proper method of preparing the subgrade for a macadam highway (*a*) across a level, sandy farm, (*b*) in a hilly and rocky country, (*c*) across a swampy country with a subsoil of clay.

3. What are the most important requirements for which provision must be made in the construction of a macadam highway?

4. In the construction of a macadam highway, how would you prevent (*a*) "ravelling," (*b*) sinking of the stone into the subgrade, (*c*) rapid powdering or disintegration of the stone, (*d*) a muddy or dusty road?

5. Explain in detail how you would take a series of accurate levels for determining the flow of water in a level country. How do you determine accurately the depth of the water over the crest of a weir?

6. A beam 12 ft. long is held in a horizontal position, one end resting against a vertical wall; the other end, which is to sustain a weight of 600 lb., is supported by two guy ropes fastened at the top of the wall 16 ft. above the beam, one 5 ft. to the right and the other 6 ft. to the left of the beam, which is perpendicular to the wall. Find the stress in the two guy ropes and the thrust of the beam against the wall.

7. What is the theoretical horse-power that may be supplied by a waterfall 90 ft. high and 84 ft. wide when it delivers 16 cu. ft. of water per second for every foot of its width?

8. The waste-gate in a sluiceway is 4.75 ft. wide; the water on one side is 9 ft. 6 in. deep and on the other 3 ft. 3 in. deep. Find the amount and the position of the resultant water pressure on the gate. Find the theoretical velocity with which the water will begin to flow when the gate is raised six inches.

9. What fall must be given a waterway 2 640 ft. long, 123 ft. wide at the top, 75 ft. wide at the bottom, 12 ft. deep, that it may convey 1 800 cu. ft. of water per second? (Take $c = 88$.)

10. A masonry reservoir wall weighs 120 lb. per cu. ft. and is 28 ft. high. It is 3.5 ft. thick at the top and has a front batter of 1 in 6. What should be the least back batter and thickness at the bottom in order that it may safely retain water level with the top?

11. The following is a portion of a set of field notes for a stadia survey. One full space on the rod corresponded to a distance of 100 ft. from the center of the instrument. The elevation of the instrument station was 131.57 ft. You are required to calculate the corrected distance, the difference in elevation and the elevation as called for by the columns below.

Stadia	Horizontal Angle	Vertical Angle	Corrected Distance	Dif. in Elevation	Elevation
.04	84° 37′	+8° 1′			
0.89	132 55	—1 33			
1.10	91 10	+3 12			
0.90	39 18	+4 52			
1.65	42 30	+3 22			
0.13	249 6	+3 32			
0.40	308 24	+9 35			
1.30	336 4	+4 57			
1.35	288 54	+3 23			
0.52	228 45	+3 53			

12. Plot to suitable scale the elevations you have determined in the above question and by them draw contour lines for each even foot of elevation. Do not erase the points plotted after drawing the contours. (If you are unable to calculate the elevations called for above, assume a reasonable set of elevations and plot as directed.)

(2 SHEETS) LAST SHEET.

STATE OF NEW YORK—STATE CIVIL SERVICE COMMISSION.

EXAMINATION FOR ASSISTANT CIVIL ENGINEER.

DIRECTIONS: Answer questions on blank paper provided, not on this sheet. In answering the questions on this sheet, any books of reference may be used. When such books are used for formulas, tables of constants, etc., candidates will give the name of the book and the page referred to. Give computations in full. Answer all of the following:

1. A stream of surface width 50 ft. and depth 4 ft. has side slopes $1\frac{3}{4}$ to 1. The sides and bottoms are of coarse gravel and pebbles with some large stone; the bed has a general fall of 0.5 per cent. Find the height of the submerged weir that will double the depth, taking into account the velocity of approach.

2. Find the pressure of the stream against the weir in the above question and design the weir, illustrating by a cross-section diagram.

3. How far can 100 horse-power be transmitted by a $3\frac{1}{2}$-in. new, straight, smooth iron pipe, laid on a grade of 1 in 2 000, with a loss of head of 25%, under an effective pressure head of 750 lb. per sq. in.

4. A dock wall, plumb at the rear with a face batter of 1 in 24 is 20 ft. high and 9 ft. thick at the base (bottom of stream). The water in front varies in depth from 10 ft. to 18 ft. The masonry of the wall weighs 125 lb. per cu. ft., and it is founded in earth weighing 112 lb. per cu. ft., having an angle of repose of 32 degrees. Find the least depth of foundation required.

5. A wall is to be 20 ft. high and 4 ft. thick at the top to retain earth with a surcharge of 10 ft., having a slope upward from the top of the wall of 1 to 1, the natural slope of the earth being 45 degrees. What should be the thickness of the wall at the bottom and the batter, if the back is to be vertical? Take the weight of the masonry at 130 lb. and that of the earth at 120 lb. per cubic feet.

6. Make an estimate of the total cost of excavating a ditch for a canal feeder, bottom width 5 ft., side slopes $1\frac{1}{2}$ to 1, depth 6 ft., length $2\frac{1}{4}$ miles, through country approximately level. The soil for most of the distance consists of 3 ft. of sand and gravel overlying stiff clay, but for $\frac{1}{8}$ mile the feeder will pass through a ledge of hard shale and slate that comes to the surface with a dip of 45 degrees. The average overhaul is $\frac{1}{2}$ mile and the time allowed for the work is 90 days. Give answer in detail.

ONE SHEET.

STATE OF NEW YORK—STATE CIVIL SERVICE COMMISSION.

PROMOTION EXAMINATION FOR FIRST ASSISTANT CIVIL ENGINEER.

DIRECTIONS: You are required to answer *six* of the following questions. Give a full discussion of each question you choose to answer. You will be allowed to use any books of reference you choose, blue-prints, diagrams and slide-rules. Time allowed, 8 hours.

1. Give the force required, method and approximate cost of making a survey for macadam road 7 miles long, 5 miles being over an existing country highway and 2 miles through unwooded farm lands, the survey over the latter to cover a strip 200 ft. wide; contour interval, 2 ft.

2. Give the force required, method and approximate cost (*a*) of making a topographic survey of 20 miles of a river valley, the stream being 500 ft. wide, depth of water 8 ft.; banks of the stream low, sloping up to high cliffs 1 000 ft. back from stream; contour interval, 2 ft. (*b*) of taking soundings across stream every 1 000 ft.

3. A concrete overflow dam is to be built in a rock gorge 800 ft. wide; height of dam, 40 ft.; flood, 3 ft. deep on spillway. Draw free-hand, approximately to scale, a section of the dam, and give in detail the method used to determine its stability.

4. Sketch and describe, giving reasons, the cross-section and foundation of a concrete retaining wall, 3 ft. wide on top; earth embankment on bank level with top; water 10 ft. deep, 1 ft. below top in front; foundation in compressible material.

5. Sketch a cross-section of a macadam road in side-hill location, stone surface to be 14 ft. wide for medium traffic. Describe and give reasons.

6. Describe a design and give a sketch of a coffer-dam resting on a bare rock foundation, to resist a head of 15 ft. of water. Give reason for design.

7. Write a brief specification for building a macadam road, covering excavation, embankment and broken stone. How would you determine when (*a*) the foundation and (*b*) the broken stone has been sufficiently compacted? (*c*) How would you repair a trap-rock road when the surface has become raveled during dry weather, (*d*) when ruts have formed?

8. If a plan for a bridge abutment showed it on a gravel foundation and you found quicksand in its place when you came to build, how would you proceed with the abutment?

9. What special precautions would you take in building a concrete wall of large cross-section (*a*) in zero weather; (*b*) in hot weather? (*c*) What general precautions would you take to insure first-class workmanship at minimum expense?

10. Write a brief specification, including material and method of bonding, for a canal embankment of earth, having a puddle-wall 3 ft. thick running lengthwise of it.

11. Show a sketch of the timber forms in which is to be built a concrete retaining wall 20 ft. high, 3 ft. thick at top, 9 ft. thick at base, giving dimensions and spacing of timbers.

12. Describe several methods of constructing and finishing the exposed face of a concrete wall. State which in your opinion is the preferable method, and why.

EXAMINATION FOR ASSISTANT ENGINEER.

1. The following sections have been taken at distances of 50 ft. apart, showing deepening of a canal in rock work:

Section	..	1	2	3	4	5	6	7	8	9	10
Area, sq. ft........	34	18	23	41	..	8	16	43	13	17	5

Using the prismoidal formula, compute the amount due the contractor, at $2.25 per cu. yd.

2. The length *A B* of one side of trapezoid being known, and the opposite angles *A C B, B C D, C D A* and *A D B* being measured, how would you proceed to obtain the length of the opposite side *C D,* by computation?

3. Find the number of revolutions per minute of a driving pulley 3.5 ft. in diameter to transmit 6 HP., the difference in the pulls on the taut and slack sides of the belt being 150 lbs.

4. Find the position of the center of gravity of a semi-circle.

Make a drawing, in plan and elevation, of a cylinder with a circular base and show how you would find the true dimensions of a section made by a plane cutting the axis at an angle of 45°.

6. Find the horse-power of an engine that will discharge 10 000 000 gallons of water per day from a depth of 40 ft. and with a velocity of 2 ft. per second.

7. A foot bridge of span 24 ft., having three 8-ft. panels; length of vertical posts 3 ft., carries a load of 100 lbs. per sq. ft. Find the stresses in the several members, showing which are in compression and which in tension.

8. Find the moment of inertia of a square plate about an edge. Also the radius of gyration.

9. Find the greatest allowable depth of water in a circular tank 20 ft. in diameter if the pressure on the metal plates of which the tank is built is not to exceed 1 ton per sq. in.

10. How do you estimate in pounds per square inch the water pressure corresponding to a given head expressed in feet?

11. A creek is carried under a canal, through three flat-bottomed, semi-circular culverts, with a diameter of 10 ft. each. Owing to a deepening of the canal of one foot it becomes necessary to carry the creek through two rectangular culverts of equal width and each 4 ft. high. What should be the width of each rectangular culvert in order to have the same aggregate carrying capacity as with the three semi-circular culverts, the grade remaining the same?

12. A culvert having a slope of 1 in 100 must take the drainage from 1,000 acres. How many cubic feet per second must be carried by the culvert, using the formula,

$$Q = c\,y\,\sqrt[4]{s\,A^3},$$

where

Q = cubic feet per second reaching culvert.
c = proportion of rainfall reaching culvert.
y = rainfall per hour.
s = average slope of watershed in feet (per 1 000 ft. horizontal distance).
A = acres of watershed = 1 000 in this instance?

(Give values to c, y and s according to your judgment of what they should be.)

LEVELER.

$4.50 to $5 a day.

Candidates must have had at least two years' practical experience in civil engineering. Candidates who have graduated in civil engineering from a school maintaining a standard satisfactory to the Commission will be credited with one year of the required experience. Subjects of examination and relative weights: Theoretical and practical questions, including mensuration and use of logarithms, plane trigonometry, topographical surveying, mapping and leveling, elementary mechanics and hydraulics, theory and use of rod, level and transit, and highway construction, 5; experience and personal qualifications, 3; education, 2. Time allowed for the written examination, 8 hours. Books of reference will be permitted as for assistant engineer, above.

(2 Sheets) Sheet No. 1.

STATE OF NEW YORK—STATE CIVIL SERVICE COMMISSION.

Examination for Leveler.

Held at.................... Date.......................
Time commenced...........
Time finished.............. Examination No............

Directions: Time allowed for the whole written examination, 8 hours. Answer questions on blank paper provided, not on this sheet. Number the answers to correspond with the numbers of the questions. In the case of problems, all the work of solution must be given. Slide-rules may be used to check results. Logarithm tables will be furnished by the examiners; no other books may be used in answering the questions of this sheet. Do not pass the tables to any other candidate, but return them to the examiner. Answer all of the following.

1. Describe the chief differences between Portland and Rosendale (or natural) cement. Give in detail the best method of mixing Portland concrete "by hand."

2. What are the most important requirements for which provision must be made in the construction of a macadam highway? In what ways is macadam most likely to fail?

3. Write a brief set of specifications for the stone to be used in a macadam highway.

4. What materials make the best binder for a macadam road? Describe in detail the proper method of applying the binder.

5. Describe in detail the "stadia" method of making a topographical survey. What are its advantages?

6. The survey of the boundaries of a large tract of land is made with a transit and tape. Discuss the compensating and cumulative errors that are likely to occur and explain the precautions you would take to overcome or reduce the latter.

7. The valve in the gate of a canal lock is 10 in. sq., and its center is 2 ft. below the water level on one side and 10 ft. below the water level on the other side. The valve and rod together weigh 10 lb. The valve-rod is attached to a lever 15 in. from its fulcrum, and the force to open the valve is applied 40 in. from the fulcrum. If the coefficient of friction is .49, what force is required to open the valve?

8. *M* is accessible, but is hidden from *N*. *N* is inacessible, but can be seen from *P* and *R*. Find the distance from *M* to *N*, the following additional data being given:

Course	*MP*	= 368.25 ft.,	bearing	N. 28° 42′ W.
"	*PR*	= 465 ft.,	"	S. 32° 10′ W.
"	*RN*		"	S. 89° 4′ W.
"	*PN*		"	S. 62° 15′ W.

9. A piece of 3 by 4 in. clear spruce lumber 13 ft. long is used as a lever with fulcrum 4 ft. from one end. What is the greatest load that may be applied at the other end before the beam breaks if the ultimate tensile strength of the timber is 10 000 lb. per sq. in.?

(2 Sheets) Last Sheet.

STATE OF NEW YORK—STATE CIVIL SERVICE COMMISSION.

Examination for Leveler.

Directions: In answering the questions on this sheet any books of reference may be used. When such books are used for formulas, tables of constants, etc., candidates will give the name of the book and the page referred to. Give computations in full. Answer all of the following:

1. A pillar 14 ft. in height is to be built up of rolled I-beams and plates and is to support a total load of 30 tons. Using 6 as a factor of safety, design the pillar, illustrating with a free-hand, pencil, cross-section sketch, giving dimensions.

2. A canal feeder in firm gravel and earth free from weeds and rock has a bottom width of 5 ft. and sides sloping 45°; the longitudinal slope of the bottom is 1 in 1 000, and the depth of the water is 5.5 ft. Find the flow in cubic feet per second.

3. The wall of a canal lock is to be of limestone masonry 24 ft. in height above 2 ft. of concrete. The land on which it is to be built consists of 18 ft. of marsh and soft loam overlying clay. Determine the size and number of piles per square yard required to support it.

4. A triangular weir has sharp edges and sides sloping 45° with the vertical. Find the flow in cu. ft. per minute when the velocity of approach is 0 and the head over the angle of the weir is 10 in.

(2 SHEETS) LAST SHEET.

STATE OF NEW YORK—STATE CIVIL SERVICE COMMISSION.

EXAMINATION FOR LEVELER.

DIRECTIONS: Answer questions on blank paper provided, not on this sheet. In answering the questions on this sheet, any books of reference may be used. When such books are used for formulas, tables of constants, etc., candidates will give the name of the book and the page referred to. Give computations in full. Answer all of the following:

1. In order to find the quantity of water conveyed by a ditch 3 ft. wide a weir with a rectangular notch 2 ft. wide and 1 ft. deep, with sharp edges, is placed across the ditch, causing the water to have a depth of $2\frac{1}{4}$ ft. above the bottom of the ditch and $8\frac{1}{2}$ in. above the crest of the notch. Find the discharge in cubic feet per second.

2. What depth and bottom width should be given the transverse profile of a canal feeder whose banks are of coarse gravel with a few weeds and slope at 40° to the horizontal, in order that it may conduct 75 cu. ft. of water per second with a mean velocity of 3 ft. per second? The feeder has a fall of 2 in 1 000.

3. A canal in clean, coarse gravel is 20 ft. wide at the bottom and its side slopes are $1\frac{1}{2}$ to 1; it has a longitudinal slope or fall of 1 in 360 and a depth of 8 ft. If a submerged weir 2 ft. high be built across the canal, what will be the increase in the depth of the water?

4. The horizontal section of a canal lock has an area of 12 150 sq. ft., and the difference of level between the surfaces of the water in the lock and in the upper reach is 9 ft. Each of the two gates is to have one sluice or valve whose center is to be 20 ft. below the surface of the upper reach, and the water is to be leveled up in 2 minutes 48 seconds. Determine the proper area of each valve.

5. A cast-iron beam of rectangular section, 12 in. deep, 6 in. wide and 20 ft. long, carries, in addition to its own weight, a single load P; the safe allowable tensile stress is 2 000 lb. per sq. in. Find the maximum allowable value of P when it is placed (*a*) at the middle point; (*b*) at $2\frac{1}{2}$ ft. from one end.

6. A hollow cast-iron pillar 12 ft. in height has to support a dead load of 35 000 lb. and a live load of 20 000 lb.; its internal diameter is $6\frac{1}{2}$ in. Find the required thickness of the metal, taking 6 as the factor of safety.

1st Sheet same as Assistant Engineer (see *ante*).

EXAMINATION FOR LEVELER.

1. Give a form of level note book showing cuts necessary to lay a pipe having a slope of 0.88 to 100, the cut at station zero being 10 ft.; assume 6 stations 25 ft. apart, the pipe rising from station zero.

2. A grade of 1-270 is how much per 100? How much per mile?

3. An ellipse has axes of 12 ft. and 6 ft. What is the radius of a circle having an area equal to that of the ellipse?

4. Explain various practical methods of finding, graphically, or otherwise, the area of a figure with irregular curved lines as boundaries.

5. What effect will be produced on the derived heights of a series of bench marks, where a New York rod has been used having .002 ft. worn off the lower end?

6. Construct a right-angled triangle being given the hypothenuse = 6 in. and the tangent of one of the angles = 0.5.

7. In making a survey the angles A, B of a triangle $A\ B\ C$ were found to be 10° 12′ and 46° 36′ and the side $B\ C$ 500 ft. Compute the other sides.

8. Make an estimate of the cost of a cubic yard of concrete, in which the cement costs 78 cts. per bbl., the sand costs $1 per cu. yd., the broken stone costs $1.35 per cu. yd., the water 10 cts. per 1 000 gallons and $\frac{3}{5}$ of a day's labor is required at $1.50 per day. Use quantities which you think should constitute the proper proportions of the different materials.

9. Draw a plan and elevation of a cylinder with a circular base.

10. A bridge 20 ft. long weighs 5 tons. A wagon weighing 1 ton is 6 ft. from one end of the bridge. Find the total loads carried by the abutments, stating the amount carried by each.

11. Express a discharge of 1 cu. ft. per second in gallons per minute.

12. Compute by finding the latitudes and departures, the area of a field from the following notes:

Station.	Bearing.	Distance in Chains.
1	N. 52° E.	1.28
2	S. 29° 45′ E.	8.18
3	S. 31° 45′ W.	15.36
4	N. 61° W.	14.48

RODMAN.

$3.50 to $4 a day.

Subjects of examination and relative weights: Theoretical and practical questions, including mensuration and use of logarithms, plane trigonometry, elementary surveying, leveling and mapping, theory and use of rod, level and transit, and highway construction, 6; experience and personal qualifications, 1; education, 3. Time allowed for the written examination, 6 hours.

(2 SHEETS) SHEET NO. 1.

STATE OF NEW YORK—STATE CIVIL SERVICE COMMISSION.

EXAMINATION FOR RODMAN.

Time allowed for the written examination, two sheets, 6 hours. Answer questions on blank paper provided, not on this sheet. Logarithmic work and other computations must be shown in full. Slide-rules may be used to check results. Logarithm tables will be furnished by the examiners; no other books may be used. Do not pass the tables to any other candidate, but return them to the examiner.

1. The following is a well-known formula for weir discharge:

$$q = 3.33\ (b - 0.2H)\ [(H + h)^{\frac{3}{2}} - h^{\frac{3}{2}}].$$

Find by logarithms the value of q to three places of decimals when $b = 5$, $H = 1.24$ and $h = .18$.

2. A sand bank is 15 ft. high; the top is in the form of a circle with a radius of 5 ft.; the bottom also is circular and measures 21 ft. across. Find the number of cubic yards contained in the bank.

3. In order to find the distance from A on one side of a hill to an inaccessible point W on the other side, a line 558 ft. long is run from A to B, and another 307 ft. long from B to C, from both of which W can be seen. The following angles are measured, $A\ B\ W = 64° 17'$, $W\ B\ C = 71° 37'$, $W\ C\ B = 75° 54' 30''$. Find the distance from A to W.

4. A beam 12 ft. long rests across a narrow vertical wall at a point $3\frac{1}{2}$ ft. from one end. The longer segment of the beam supports a weight of 64 lb. at its outer end and the beam is kept horizontal by a rope from the other end which is fastened to the wall $3\frac{1}{2}$ ft. from its top and the beam is kept from slipping by a cleat underneath it. Neglecting the weight of the beam, find the tension in the rope and the vertical pressure upon the wall.

5. From the following notes of the survey of a field, calculate the area in acres.

Course.	Bearing.	Distance.
A to B	S. 69° 15′ E.	706 ft.
B to C	N. 37° 15′ E.	593 ft.
C to D	N. 39° 30′ W.	600 ft.
D to E	S. 57° 45′ W.	465 ft.
E to A	S. 30° 00′ W.	498 ft.

6. It is required, using a steel tape, to measure with great accuracy the distance between two points about two miles apart; mention and describe in detail the precautions that should be taken.

(2 SHEETS) LAST SHEET.

STATE OF NEW YORK—STATE CIVIL SERVICE COMMISSION.

EXAMINATION FOR RODMAN.

7. Mention and describe three methods employed or precautions taken to keep the subgrade of a macadam road dry. Why is it important that the subgrade be kept dry?

8. A trench for a canal feeder is to be dug, bottom 8 ft. wide with side slopes $1\frac{1}{2}$ horizontal to 1 vertical. Suppose levels have been taken on the centre line; explain in detail how you would set and mark the slope stakes.

9. What is meant by "raveling" in a macadam road? Describe in detail the means that are employed to prevent and correct it.

10. In a survey two tangents (or courses) intersect at stake 112 + 45 and the deflection angle is 40° 30′. These tangents are to be connected by a 12° curve, which is to be located by offsets from the first tangent, the points to be determined for each 50 ft. of length. Find the first three offsets and the points on the tangent from which they are to be measured.

11. Describe in detail the best method of mixing by hand concrete for the foundation of a masonry retaining wall, and state the usual proportions of the ingredients.

12. State in their proper order and explain in detail the adjustments of the engineer's transit.

13. Plot the following stadia notes to about the scale 100 ft. = 1 in., and from the points when plotted draw contour lines for

each even foot of elevation. Do not erase the points plotted after drawing the contours.

Horizontal angle.		Distance.	Elevation.
36°	34′	79.68	116.48
39	40	159.36	119.77
83	25	99.40	118.96
156	28	45.91	110.47
147	8	65.93	112.60
126	37	185.26	122.92
103	18	175.65	115.13
88	18	199.60	119.19
61	48	220.56	120.34

(2 SHEETS) SHEET NO. 1.

STATE OF NEW YORK—STATE CIVIL SERVICE COMMISSION.

EXAMINATION FOR THE POSITION OF RODMAN.

1. Find by logarithms the value of d to three decimal places from the formula:

$$d^5 = \frac{q^2\ (m \sin z + 2)}{c^2\ s\ (m + \cot z)^3 \sin z}$$

when $q = 228$
$m = 1.15$
$z = 52°$
$c = 77$
$s = .0015$

2-3. From the following data find the distance from A to B correct to one decimal place.

	Bearing.	Distance.
A C	N. 33° 41′ E.	195.4 ft.
A D	N. 75° 32′ W.	129.9 ft.
B C	S. 76° 0′ E.	
B D	S. 5° 47′ E.	

4. Find correct to one decimal place the number of cubic yards of sand in a bank having a level top 5 ft. wide and 20 ft. long in the shape of a rectangle, 15 ft. long, with semi-circular ends, if the bank is 12 ft. high and has a uniform slope on all sides of 1.5 horizontal to 1 vertical.

5. The following are from the field notes of a stadia survey in which the constant correction, k, for the instrument was 1.2 ft.

Stat. No.	Stadia Reading.	Vert. Angle.
1	131.4	— 2° 37′
2	168.4	—18° 26′

Find the corrected distance and elevation for both observations by the accurate formulas:

$$\text{dist.} = \text{reading} \cos^2 a + K \cos a$$
$$\text{elev.} = \tfrac{1}{2} \text{ reading} \sin 2\,a + K \sin a$$

and also by the approximate formulas:

$$\text{dist.} = \text{reading} \times \cos a + K$$

and $$\text{elev.} = \text{reading} \times \sin a$$

and find the percentage of error in each case, due to the approximation.

(2 Sheets) Last Sheet.

STATE OF NEW YORK—STATE CIVIL SERVICE COMMISSION.

Examination for the Position of Rodman.

6. State and explain in their proper order the five adjustments of the engineer's transit.

7. Sketch carefully in pencil a profile and explain how it is used in establishing the grade for a highway and in estimating and balancing cuts and fills.

8. What is meant by the "declination of the magnetic needle?" Describe the variations of the magnetic declination. In the field how would you determine the true north? Explain in detail.

9. What is the use of a binder in a macadam road? How should the binder be applied? What mistakes are sometimes made in applying the binder?

10. Discuss the proper size, shape and quality of stone to be used in the construction of a macadam road. Why are these requirements of the stone important?

11. What is meant by telford in macadam road construction? When should telford be used?

12. What will probably result if in the construction of a macadam road the following are allowed: (*a*) roots and sods in the subgrade; (*b*) poorly drained subgrade; (*c*) insufficiently rolled subgrade; (*d*) lack of crown to road; (*e*) soft and hard stones used together in the road?

EXAMINATION FOR RODMEN.

In this and the examinations for Leveler and Assistant Engineer below, the work of computation must be shown. (Books of tables are furnished by the Board for the use of the candidates and no other books are to be used.)

1. Divide $\frac{3}{8}$ by $\frac{4}{16}$.

2. Multiply 0.3642 by 0.0072.

3. Extract the square root of 0.00000.

4. Reduce 325° 46′ 23″ to seconds.

5. Find eleven times the sum of 23° 00′ less 10″ and 0° 02½′ less 57″.

6. Having the area of a circle, how would you find its diameter?

7. Having one diameter and the area of an ellipse, how would you find the other diameter?

8. Find the values of x and y from the equations:

$$x^2 + y^2 = 25$$
$$x + y = 7$$

9. What is the length in rods of the side of a square which contains 59⅜ acres?

10. If the grade of a railroad is 73 ft. in a mile, how much is it in each 100 ft.?

11. A distance of 5 280 ft. has been measured on an even incline of 3 to 100, what is the correct horizontal distance?

12. A tank measures 7 ft. 9 in. long by 6 ft. 4 in. wide by 8 ft. 4 in. deep. If water flows into this tank at the rate of 1 gal. in 3 seconds, how long a time will it take to fill the tank, and what will be the entire pressure on the bottom of the tank?

13. An earth embankment measures, in embankment, 1 693 cu. yd.; the material shrinks in embankment 6%. How much would it have measured in the original bank from which it was taken?

14. A barn is 40 ft. wide. The pitch of the roof is 45°; find the length of the rafters.

15. Give the approximate weights of 1 gal. water, 1 cu. ft. water, 1 cu. ft. cast iron, 1 cu. ft. granite, 1 cu. ft. brick.

16. Taking a kilogram to be equivalent to 2.2 lb., find the number of grams in 1 oz.

17. A gravel bed has a surface of 6 acres and an average depth of 6 ft. How many miles of road can be covered with this gravel to a width of 11 ft. and a depth of 6 in.?

18. Express a speed of 10 miles an hour in centimeters per second.

19. In the Phœnix Iron Co.'s pocketbook it is stated that the specific gravity of cast iron is 7.2; what does this mean?

CHAINMAN.

Minimum age, 18 years. $2.50 to $3 a day. Subjects of examination and relative weights: Arithmetic, mensuration and use of chain, 8; experience and education, 2. Time allowed for the written examination, 6 hours.

1 SHEET.

STATE OF NEW YORK—STATE CIVIL SERVICE COMMISSION.

EXAMINATION FOR THE POSITION OF CHAINMAN.

Answer questions on blank paper provided, not on this sheet.

1. A wall 1 690 ft. long is to be built in 30 days, and it is found that 7 men in 14 days have completed only 490 ft.; how many additional men must be employed for the remainder of the time so that the wall may be completed in the required time?

2. Find the cubic yards of masonry in a wall 88½ ft. long, 10 ft. high, 1 ft. 6 in. thick at the top, 3 ft. 6 in. thick at the bottom, with sides sloping uniformly from the top to the bottom.

3. Two adjoining lots of city land 132 ft. deep contain respectively 31 sq. rd. 112½ sq. ft., and 35 sq. rd. 36 sq. ft. These two lots together are to be redivided into five equal building lots. What will be the width in feet of each lot?

4. If the rainfall on a certain day was ¼ in., how many gallons of water fell on a rectangular piece of land 22 rd. 9 ft. wide and ¼ mile long? (1 gal. contains 231 cu. in.)

5. What is the length of an arc of 30° in a circle whose diameter is 18 ft.? (Give answer to 3 decimal places.) (The circumference is 3.1416 times the diameter.)

6. (*a*) If you were sent to make a chain survey of a piece of rough meadow land what tools or instruments would you need to take with you? (*b*) Explain carefully and in detail how you would begin the work and how proceed with the measurement of the first course? (*c*) How would you keep the measurement always in a straight line with the points from which and to which you are chaining?

7. Suppose that you have arrived at a corner or angle in the meadow and have with you neither transit nor surveyor's compass, how would you measure the angle in the line you are chaining so that a map could be made from the measurements and notes you are taking?

8. (*a*) How would you proceed if your line crosses a broad gully very steep on one side. Explain carefully and in detail. (*b*) Suppose that your line passes over a hillock that shuts out from view the rod toward which you are chaining; how would you overcome the difficulty? (*c*) How would you proceed if a large tree stood in the way of the line you were chaining?

9. (*a*) What would you do if a 100-ft. length, in your measurement, should end in the middle of a brook that flows swiftly over a smooth stone bottom? (*b*) What would you do if your line crossed a bed of quicksand or a deep marsh more than a chain length across? Explain carefully.

10. (*a*) How would you lay out a line at right angles to the course you have just measured? (*b*) Having finished your survey, how would you fold your chain?

11. If your 100-ft. chain is $\frac{5}{8}$ in. too short what is the true length of a line that you have measured and recorded as 2 416.5 ft. in length?

12. Have you had any experience as chainman or assistant in a survey? If so describe in detail, giving time, place and length of service. What experience or other education have you had that you consider qualifies you for duties of chainman?

(ONE SHEET.)

STATE OF NEW YORK—STATE CIVIL SERVICE COMMISSION.

EXAMINATION FOR THE POSITION OF CHAINMAN.

DIRECTIONS: Answer questions on blank paper provided, not on this sheet.

N. B.—In solving problems the entire process and entire computation must be given on the answer sheet handed in. Mark the answer to each problem: "Ans."

1. The sides of a triangular field, one of whose angles is a right angle, are respectively 36, 48 and 60 rods; how much is it worth at $75 an acre? (160 sq. rd. equal 1 acre.)

2. If 8 yd. of cloth $1\frac{3}{4}$ yd. wide cost $30, what will be the cost of $14\frac{3}{4}$ yd. of cloth of the same quality, $2\frac{1}{4}$ yd. wide?

3. A line was measured and recorded as 1 mi. 60 rd. 2 ft. in length. It was afterwards determined that the 100-ft. chain, with which the line was measured, was .7 in. too long; what was the true length of the line?

4. Find the cost of 50 boards, each 16 ft. long, 8 in. wide and $1\frac{1}{2}$ in. thick, at $2\frac{1}{2}$ cents per ft., board measure.

5. A railroad train ran 56.3 miles in the first hour, 62.34 miles in the second, 59.247 miles in the third, and 60.7304 miles in the fourth. Find the average rate of speed per hour.

6. Take .794569376 from 15.6000304.

7. If the steel of which a tape is made expands .00001082 of its length for each degree increase of temperature, what will be the length of a steel tape at 43.5 degrees if its length at 0 degrees is 99.897 feet?

8. A rectangular field contains $1\frac{1}{16}$ acres; what is its length if its width is 175.25 ft.? (One acre equals 43 560 sq. ft.)

9. A rectangular field $7\frac{1}{2}$ times as long as it is wide contains 300 acres. What is the distance around the field?

10. Describe in detail how two chainmen using chain and pins would measure the exact distance between two fixed points across a field which is level or nearly so.

11. How are angles measured by use of the chain alone?

12. Describe a good method of taking offsets with a chain in order to pass obstructions, such as buildings or large trees. Use diagram to illustrate your answer.

13. How could you lay off on the ground an angle of 60° by means of the chain alone? An angle of 90 degrees?

14. What are the principal sources of error in chain measurements?

15. What advantages has the steel tape over the chain for accurate measurements?

EXAMINATION FOR CHAINMAN.

1. What is the length of a surveyor's chain?

2. How many feet are there in a quarter of a chain?

3. Add $5\frac{1}{2}$, $3\frac{1}{8}$ and $7\frac{1}{4}$.

4. Divide 5 280 by 66.

5. Make a sketch showing the points of the compass.

6. Find the number of cubic feet capacity of a box whose inner dimensions are length 16 in., breadth 16 in., and depth 13.5 in.

7. If a tape line is divided into feet and tenths, how many tenths will there be in $15\frac{1}{2}$ ft.?

8. What will 42 642 bricks cost at $6.50 per 1 000?

9. Describe the process of measuring distances with a tape line or chain, on hilly ground.

10. What are grade stakes and how are they driven?

ENGINEERING DRAFTSMAN.

$4 to $5 a day.

Subjects of examination and relative weights: Practical and theoretical questions, including mensuration and the solution of plane triangle, use of logarithms, free-hand lettering, reduction of field notes and plotting, mapping, 7; experience and education, 3. Time allowed for the written examination, 8 hours.

SPECIMEN QUESTIONS.

Directions: The work of computation must be shown in full. Logarithm tables will be furnished by the examiners.

1. Two straight roads meet at an angle of 58¼ degrees. Find the distance betwen a tree on one of the roads a half-mile from their point of meeting, and a flag-pole on the other road 3 640 ft. from the same point.

2-4. From the following bearings and distances, balance the survey, plot to suitable scale and compute the area in acres by the method of co-ordinates:

Station A..........	N. 51° 50′ E.	Distance, 1,063 ft.
Station B..........	S. 29° 45′ E.	Distance, 410 ft.
Station C..........	S. 31° 44′ W.	Distance, 769 ft.
Station D..........	N. 61° 0′ W.	Distance, 713 ft.

Letter the bearings and distances on your map in stump writing.

5. Indicate the following by means of neat free-hand pen drawings, each to occupy a space 1 in. by 1½ in.: (*a*) quarry-faced masonry; (*b*) brickwork in Flemish bond; (*c*) broken range masonry; (*d*) forest with both evergreen and deciduous trees; (*e*) marsh with stream through it.

6. Draft the following title in letters of three different sizes, using stump or round writing or some other style of free-hand lettering that you can do neatly and rapidly: "Plans for improving the highway between Buffalo and Albany, a distance of 310 miles, passing through Medina, Rochester, Clyde, Syracuse, Oneida, Whitesboro, Utica, Little Falls and Schenectady. Scale 1 in. = 100 ft.

7-8. Draw plan, elevation and cross-sections for a semi-circular arch-culvert, of 15 ft. span, under a highway 22 ft. wide, allowing 2 ft. between the top of the arch and surface of road, with parapets 2 ft. 6 in. wide, 3 ft. high. Design suitable wing-walls for a flood 3 ft. deep. Supply all other needed data.

9-10. Draw 5-ft. contour lines from the elevation points given on this sheet; mark the elevations for each contour and indicate the probable location of streams.

From the contour sheet as you have prepared it, draw on separate sheet two sections of the ground, one through the line N. S., the other through E. W. Indicate the vertical scale used.

(2 SHEETS) SHEET No. 1.

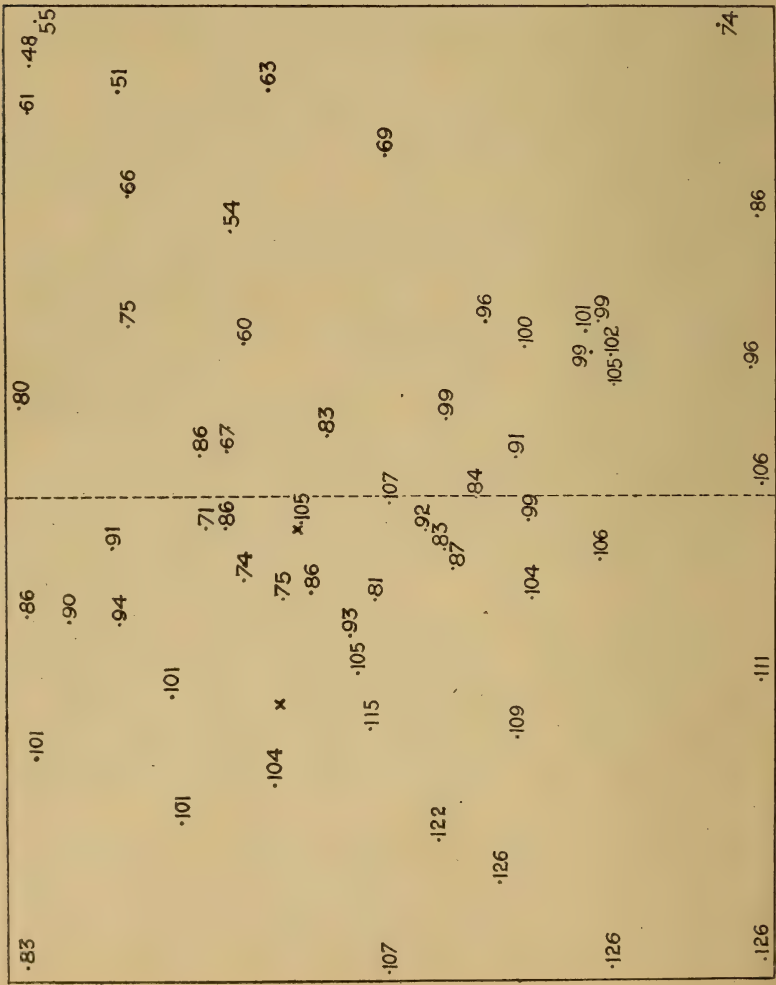
STATE OF NEW YORK—STATE CIVIL SERVICE COMMISSION.

EXAMINATION FOR CIVIL ENGINEERING DRAFTSMAN.

Time allowed for whole examination, 8 hours.

1-2. Draw 5-ft. contour lines (at 90, 95, 100 ft., etc.) from the elevation points given on this sheet; mark the elevation of each contour and indicate the probable location of streams. Ink in contours.

Scale 1 in.=10 ft.



3-4. Design an arch culvert with roadway 12 ft. wide with suitable wing walls to occupy the location indicated by the red x's on the accompanying contour sheet. The elevation of the roadway over the culvert is to be 104.

5. Draft the following title in letters of suitable sizes, using stump or some other style of free-hand lettering that you can do neatly and rapidly:

"Section Map Showing Location of Culvert No. 3, Pierrepont Manor and Ellisburgh Road. Scale 1 in. = 10 ft."

(2 Sheets) Last Sheet.

STATE OF NEW YORK—STATE CIVIL SERVICE COMMISSION.

Examination for Civil Engineering Draftsman.

Directions: Answer questions on ruled or drafting paper provided; the work of computation must be shown in full. Logarithm tables will be furnished by the examiner; no other books may be used. Do not pass the tables to any other candidate, but return them to the examiner.

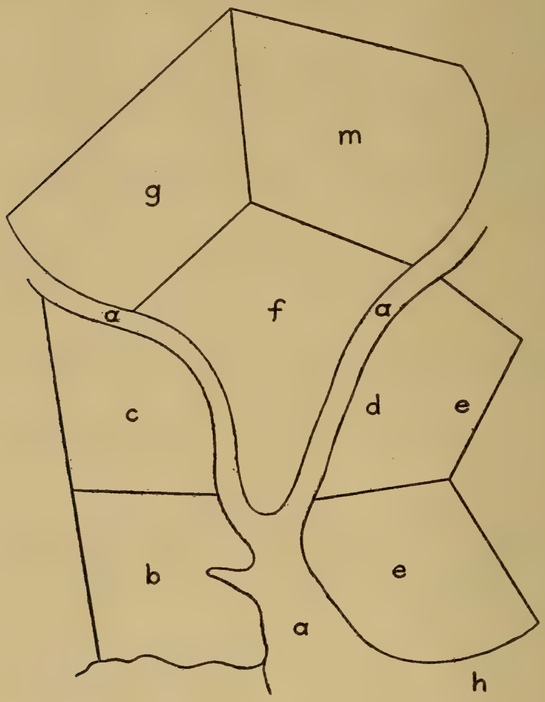
6-7. Plot the following stadia notes, after making the necessary correction, to the scale 1 in. = 40 ft. Distances must be correct to the nearest tenth of a foot; elevations and contours are not called for. The constant for the instrument is 1.2 ft.

Observations at Station A.

Shot No.	Stadia reading.	Horizontal angle.	Vertical angle.
1	127.8	86° 29′	— 0° 32′
2	199.5	33° 41′	— 9° 22′
3	168.4	326° 32′	—18° 26′
4	131.0	284° 28′	—11° 38′
5	131.4	212° 50′	— 2° 37′
6	161.8	180° 3′	0° 0′
7	177.7	154° 27′	+6° 7′

8-9. Copy the accompanying map to the scale 1 in. equals 2 miles, and in place of the letters, fill in the proper topographical signs to indicate: (*a*) water; (*b*) marsh with stream; (*c*) hops;

(*d*) cliff; (*e*) hills with deciduous trees; (*f*) meadow; (*g*) fallow, or rough cleared land; (*h*) sand bar; (*m*) farm with buildings, etc.



Scale 1" = 3 Miles

10-11. Problem 6-7 gave the stadia shots from Station A of a survey. Station A is invisible from Station B. In order to locate Station B, the transit, set up at B, was turned back on the points numbered 1 and 2 of observations from A and the following horizontal angles were read:

"Shot No. 1." 128° 29′ "Shot No. 2." 104° 0′

Find the distance and bearing of the course AB.

BRIDGE DESIGNER.

$1 500 to $1 800.

Candidates must have had at least five years' practical experience in drafting, designing and constructing structural steel and bridge work. Candidates who have graduated in civil engineering from a school maintaining a standard satisfactory to the Commission will be credited with one year of the required experience. Subjects of examination and relative weights: Questions on graphical and analytical determination of stresses in simple highway trusses and plate girders, and design of plate girders, floor beams, truss members, foundations, bearings, etc., with drafting, 6; experience, education and personal qualifications, 4. For part of the examination candidates may use tables and books of reference as desired. The Carnegie and Pencoyd handbooks are suggested. Time allowed for written examination, 8 hours.

SPECIMEN QUESTIONS.

Theoretical and Practical Questions.

1. Find the stresses analytically in a through skew Pratt truss of 7 panels, the axis of the truss making an angle of 60° with the abutments, the 5 middle panels being each 25 ft. long, and the end panels 30 ft. and 20 ft. respectively. Height 30 ft.; width 20 ft. in the clear. Dead load 1 000 lb., live load 4 000 lb. per lin. ft.

2. The accompanying figure represents the half-truss for a bridge of 80-ft. span, depth at B and at center = 12 ft., depth at A = 6 ft. Find graphically the stresses in each member due to a load of 5 tons at each panel point, divided between two trusses.

3. Find the stresses in a parabolic arch bridge of 10 panels; span 120 ft., rise 24 ft., hinged at both ends and at the middle joint. Dead load 1 000 lb., live load 2 000 lb. per horizontal foot.

4. Find the tension at the middle and ends of each cable of a suspension bridge of 200 ft. span. Dip of cables 80 ft., weight of roadway $\frac{1}{2}$ ton per ft., live load $\frac{1}{2}$ ton per ft. Show by a free-hand drawing how the cables should be anchored.

5. The counterbalanced swing-bridge, shown below, is 16 ft. deep and wholly supported upon the turn-table at A and B; the dead weight is 650 lb. per lin. ft. The counterpoise is hung from C and D; find its weight, assuming that a portion of it is transmitted to A through B E, sufficient to make the reactions at A and B equal.

6. The members of a bridge consist of 4 eyebars 4 in. by $1\frac{3}{16}$ in. on one side of a panel point, 2 eyebars 4 in. by $1\frac{7}{16}$ in. on the other side, the diagonals are $1\frac{9}{16}$ in. thick, half the post is $\frac{7}{8}$ in., the vertical compression in the half post is 40 000 lb. for full loading; assuming the unit stress at 10 000 lb. per sq. in., calculate the size of the pin required and pack the pin.

7. Give a short description of the kind of floor system you consider best suited for city bridges subject to heavy loads. What is the usual allowance for clearance under city bridges?

8. How do you proportion expansion rollers?

9. If you were sent out to inspect and report on an existing structure, what are the principal points you would investigate and how would you proceed to do it? What are the principal points to be observed in painting a bridge?

10. A plate girder of 64 ft. span and 8 ft. depth carries a load of 2 tons per lin. ft. At any section the two flanges are of equal area and their combined area is equal to that of the web. Find the sectional area at the center of the girder so that the intensity of stress in the metal may not exceed 3 tons per sq. in. Design the girder and illustrate by carefully-made drawings.

(2 SHEETS) SHEET No. 1.

STATE OF NEW YORK—STATE CIVIL SERVICE COMMISSION.

EXAMINATION FOR BRIDGE DESIGNER.

Held at..................... Date........................
Time commenced...........
Time finished................ Examination No.............

Answer questions on blank paper provided, not on this sheet. Logarithm tables will be furnished by the examiner, but no other books may be used in answering the questions of this sheet. Time allowed for the whole written examination, 8 hours.

1. Discuss the arguments for and against the use of double and triple system trusses in railroad and highway bridge design.

2. Calculate analytically the stresses in a double system through Warren truss, 125 ft. long and 18 ft. deep, of 10 panels each, 12.5 ft. long, due to a uniform dead load (for each truss) of 800 lb. per lin. ft. Place results on a truss diagram.

3. Determine graphically the stresses in a through bridge truss of 7 panels each 27 ft. long, of the Pratt type, but with a broken upper chord, making the verticals respectively 29 ft., 35 ft., 38 ft., 38 ft., 35 ft. and 29 ft., due to a dead load of 1 200 lb. per lin. foot, of which 400 lb. is to be carried by the upper chord.

4. A through Pratt truss has 9 panels each 24 ft. long and 32 ft. deep. The dead panel load is 2.4 tons on the upper chord and 5.6 tons on the lower chord and the live panel load is 18 tons. Compute the maximum and minimum stresses in the fourth vertical and in the main and counter diagonals in the fourth panel.

5. Design, making plan, elevation and section drawings for a bridge pier, including its foundation on soil consisting of 2 ft. of silt and 10 ft. of sand overlying hardpan; the bottoms of the trusses, each 140 ft. long, are to be 35 ft. above the surface of the water, which is 9 ft. deep. By the proper conventional signs, indicate the materials of construction.

(2 SHEETS) LAST SHEET.

STATE OF NEW YORK—STATE CIVIL SERVICE COMMISSION.

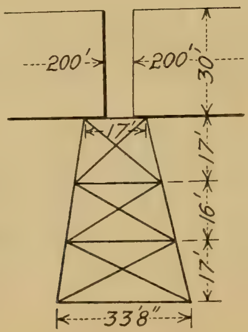
EXAMINATION FOR BRIDGE DESIGNER.

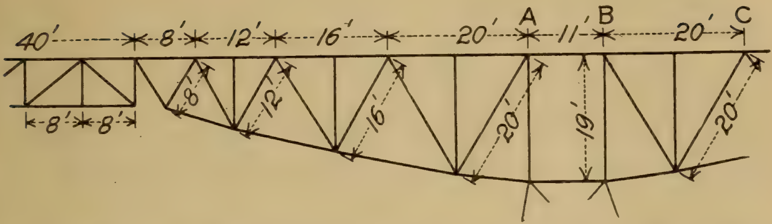
In answering the questions of this sheet, any books of reference may be used. When formulas or constants are taken, give the book and page where they are found.

6. Design a steel column 30 ft. high to sustain a dead load of 120 tons and a live load of 100 tons, without external bracing. Make to scale diagram of its cross-section and give all required computations.

7. A floor beam of soft steel in a railroad bridge has a span of 16 ft. and weighs 2 600 lb. Each stringer is 22 ft. long and weighs 3 800 lb. The stringers are spaced 7 ft. apart. The track is to be taken at 450 lb. per lin. ft. The maximum floor beam reaction due to the live load is 46 600 lb. The floor beam has a web $\frac{7}{16}$ in. thick and an effective depth of 38 in. or $39\frac{1}{2}$ in. out to out. Compute the rivet spacing in the flanges. How many changes in rivet pitch would you adopt? Assume the proper working stresses.

8. The accompanying figure represents a pier, square in plan, supporting the ends of two deck trusses, each 200 ft. long and 30 ft. deep. The height of the pier is 50 ft. and is of three panels as shown. Ten sq. ft. of bridge surface and 10 sq. ft. of train surface per lin. ft. are subjected to a wind pressure of 40 lb. per sq. ft. The center of pressure for the bridge is 68 ft., and for the train 86 ft. above the base of the pier. The wind produces also a horizontal pressure of 4 000 lb. at each of the intermediate panel points on the windward side of the pier. Width of pier, 17 ft. at top and 33 ft. 8 in. at bottom. Dead load of bridge 1 600 lb. per lin. ft. and live load 3 000 lb. per lin. ft. Draw a diagram giving the wind-stresses in all the members of the pier and indicate which are in compression and which in tension.





9. The above diagram represents one of a pair of cantilevers that support a free Pratt truss of 5 panels each 8 ft. long and 7 ft. deep. The cantilever is made up of eight equilateral triangles of sides respectively 8 ft., 12 ft., 16 ft., 20 ft., 20 ft., 16 ft., 12 ft., and 8 ft., and a pier panel 11 ft. long and 19 ft. deep. Find the maximum stresses in the chords A B and B C, due to a live load of 600 lb. per lin. ft. per truss crossing the bridge.

10. A deck plate girder bridge for a double-track railroad, span 120 ft., effective depth 140 in., is to be designed in 10 panels or sections of equal length. Find the shear and required web-section in an end panel and the bending moment and required flange-section in the fourth panel from one end for one girder due to live loads composed of two standard engines, described below, followed by a uniform trainload of 3 600 lb. per lin. ft. Pilot wheel loads 18 000 lb.; driver loads, 34 000 lb.; tender loads, 21 000 lb.; from pilot wheel to driver, 8 ft.; four drivers spaced 5 ft. apart; drivers to tender 8 ft.; four tender wheels spaced 5 ft.; from tender to next engine, 8 ft.; from second tender to train, 4 ft.

BRIDGE DRAFTSMAN.

$1 200 to $1 500.

Candidates must have had at least three years' practical experience in drafting on structural steel and bridge work. Candidates who have graduated in civil engineering from a school maintaining a standard satisfactory to the Commission will be credited with one year of the required experience. Subjects of examination and relative weights: Questions on riveted joints, standard bridge details, roller bearings, conventional signs and drawings, 6; experience, education and personal qualifications, 4. For part of the examination candidates may use tables and books of reference as desired. Time allowed for written examination, 8 hours.

(2 Sheets) Sheet No. 1.

STATE OF NEW YORK—STATE CIVIL SERVICE COMMISSION.

Examination for Bridge Draftsman.

Directions: Logarithm tables will be furnished by the examiner; no other books may be used in answering the questions of this sheet. Time allowed for the written examination, 8 hours.

1. In some neat, suitable style of free-hand lettering, write the title, "Design and Specifications for a Double System Warren Highway Bridge, Span 128 ft."

2. Find the web and chord stresses in a through riveted Warren highway truss of 5 panels, each 20 ft. long and 15 ft. high, due to a dead load of 10 000 lb. per panel, 7 000 lb. of which is to be taken by the lower chord and 3 000 lb. by the upper chord.

3. The above bridge is to have a width in the clear of 18 ft. and the live load is to be taken at 96 lb. per sq. ft. of floor. Design the floor beams and stringers and show how they should be attached to the other members of the bridge.

4. Design a suitable ornamental entrance for a through city highway bridge which shall be made of standard shapes or simple modifications and shall serve also as portal bracing. Make detail drawings, if necessary, to show how this shall be constructed.

(2 SHEETS) LAST SHEET.

STATE OF NEW YORK—STATE CIVIL SERVICE COMMISSION.

EXAMINATION FOR BRIDGE DRAFTSMAN.

In answering the questions of this sheet, any books of reference may be used.

5. Design a deck plate girder, span 80 ft., depth 6 ft., which is to be one of two girders to support a highway span 18 ft. wide on which there may be a live load of 90 lb. per sq. ft. Make plan, elevation and section drawings to the scale 1 in. equals 4 ft., showing method of building up the girder, of attaching the lateral bracing, etc.

6. Give in detail the calculations for the determination of the flange area, allowance for rivets and numbers of rivets near the center of the above plate girder.

7. In a riveted Pratt truss of 9 panels, each 16 ft. long and 18 ft. deep, the following maximum stresses have been determined in tons, + meaning tension, — meaning compression. The stresses in the first five panels are, upper chord — 73.2, — 94.2, — 104.7, — 104.7; lower chord + 41.85, + 41.85, + 73.2, + 94.2, + 104.7; diagonals — 69.75, + 52.2, + 34.8, + 17.4, + 9.3; verticals + 9.9, — 32.1, — 18, — 4.05. Design the members that meet at the lower panel point 48 ft. from the abutment. Make, to suitable scale, detail drawings of the joint at that point.

8. If the maximum allowable pressure in pounds p per linear in. of roller is 600 d, where d is the diameter of the roller, design the expansion rollers for a city highway span 120 ft. long with roadway 18 ft. wide in the clear and sidewalk on each side 4½ ft. wide. The dead load is to be taken at 780 lb. per lin. ft. and the live load at 90 lb. per sq. ft. of roadway, including sidewalks.

(2 Sheets) Sheet No. 1.

STATE OF NEW YORK—STATE CIVIL SERVICE COMMISSION.

Examination for the Position of Bridge Draftsman.

Directions: Logarithm tables will be furnished by the examiner. Candidates may use the Pencoyd or Carnegie Handbooks, but no other books will be allowed. Time allowed, 8 hours.

1. Calculate the stresses in the middle panel of a through riveted Pratt truss of 133 ft. span, 20 ft. depth and 7 panels, due to a dead load of 1 000 lb. per lin. ft., and a live load of 2½ tons concentrated at one end of the middle panel, the loads to be distributed equally between two trusses 20 ft. apart.

2. Design the lower chord and one of the vertical members for the middle panel of the Pratt truss described in question (1), showing the connections at the panel-point.

3. A Warren girder 80 ft. long is formed of equilateral triangles with sides 16 ft. long. Weights of 2, 3, 4 and 5 tons are concentrated, respectively, at the first, second, third and fourth apices along the upper chord. Determine the stresses in the diagonals due to these loads.

4. A frame in the form of an inverted queen truss is composed of a horizontal top-beam 40 ft. long, two vertical struts 3 ft. long, and three tie-rods of which the middle one is horizontal and 15 ft. long. (*a*) Find the stresses produced in the several members when a single load of 6 000 lb. is concentrated at the head of each strut. (*b*) If a wheel loaded with 12 000 lb. travels over the top-beam what members must be introduced to prevent distortion? What are the maximum stresses to which these members will be subjected?

(2 Sheets) Last Sheet.

STATE OF NEW YORK—STATE CIVIL SERVICE COMMISSION.

Examination for the Position of Bridge Draftsman.

5. The platform of a bridge for a clear span of 60 ft. is carried by 2 queen trusses 15 ft. deep; the upper horizontal member of each truss is 20 ft. long; the load upon the bridge is 50 lbs. per sq. ft. of platform, which is 12 ft. wide. Find the stresses in the several members.

6. Find graphically the stresses in a pony parabolic bow-string truss of 8 panels, 80 ft. span and 10 ft. rise, (*a*) for a dead load of 1 000 lb. per lin. ft.; (*b*) the maximum and minimum stresses in the diagonals in the third panel from one end due to a concentrated load of 3 tons crossing the bridge.

7. Choose and sketch section of the end-post of a bridge to withstand a compression of 120 tons; length 28 ft., taking the unit stress from the following formula: $P = 10\,500 - 60\frac{l}{r}$, where l is the length of member in inches and r is the radius of gyration in inches.

8. Letter in some suitable style the title: "Design for a Steel Through Pratt Truss Highway Bridge, span 110 feet."

JUNIOR BRIDGE DRAFTSMAN.

$900 to $1 200.

Minimum age, 20 years. Candidates must have had some practical experience in mechanical or structural drafting. Subjects of examination and relative weights: Practical questions covering free-hand sketches of structural shapes and simple members built up of shapes, free-hand lettering, detail drawing, tracing and calculation of weights, 8; experience and education, 2. Time allowed for the written examination, 8 hours.

(2 SHEETS) SHEET NO. 1.

STATE OF NEW YORK—STATE CIVIL SERVICE COMMISSION.

EXAMINATION FOR JUNIOR BRIDGE DRAFTSMAN.

Time allowed, 8 hours. No books are needed, and none may be used.

1. A column 24 ft. in height is made up of four $6\frac{1}{8}$-in. Z-bars of $3\frac{5}{8}$ in. face and $\frac{7}{8}$ in. thickness, one plate 14 in. by 1 in. and four plates 20 in. by $\frac{7}{8}$ in. Draw the cross-section of the column, showing how you would build it up; also the elevation showing the rivet spacing. Calculate the weight of the column, if the metal weighs 495 lb. per cu. ft.

2. To the column described above, a beam is to be attached, composed of two 12-in. I-beams (with 5-in. flanges) and plates. Make a detail drawing of the splices and connections.

3. Make neat free-hand drawings of the standard "shapes" in which structural steel is furnished by the rolling mills, and give the proper name to each. Show five ways in which these are combined in building up beams and columns.

4. In some neat, suitable style of free-hand lettering, write the title: "Detail sheet for Through Pratt Truss for a Highway Bridge, span 80 feet."

5. A Warren girder 80 ft. long is formed of equilateral triangles, with sides 16 ft. long. Weights of 2, 3, 4 and 5 tons are concentrated, respectively, at the first, second, third and fourth apices along the upper chord. Determine the reactions of the abutments and the bending moment at the center due to these loads.

(2 Sheets) Last Sheet.

STATE OF NEW YORK—STATE CIVIL SERVICE COMMISSION.

Examination for Junior Bridge Draftsman.

6. Make plan and elevation drawings for a bridge pier 24 ft. high above the mean water surface, 32 ft. long and 6 ft. wide at the top, with a batter of 1 in. to 1 ft. on each side. The down-stream end has a batter of 1 in. to 1 ft. and is semicircular; the up-stream end is triangular and has a batter of 3 in. to 1 ft. Indicate in the drawing that the coping is to be of dressed stone, the rest of the pier to be of rough-faced stone.

7. Calculate the number of cubic yards of masonry in the pier above.

8. Make neat detail drawings of the connections at one of the upper panel points of a riveted Pratt highway truss, showing connections of post with upper chord, diagonals and lateral bracing.

9. Design a plate girder for a girder highway bridge, the girders to be 72 ft. long and 4½ ft. deep. Show the method of building up the girder, splice plates, stiffeners, rivet-spacing, floor beam connections, etc.

10. Design the hand-railing and end-post for a railing for the sidewalk on the approach to a city highway bridge.

(2 Sheets) Sheet No. 1.

STATE OF NEW YORK—STATE CIVIL SERVICE COMMISSION.

Examination for Junior Bridge Draftsman.

Time allowed for the whole examination, 8 hours. No books are needed, and none may be used.

1. In some neat, suitable style of free-hand lettering, write the title: "Design, Including Estimates and Details, for a Suburban Highway Bridge. Span 120 ft. Submitted by Wm. M. Green, C. E."

2. A through riveted Pratt highway truss has 7 panels, each 15 ft. long and 27 ft. deep. The maximum stress determined for the lower chord of the middle panel is 36 700 lb., for the lower chord of the adjacent panel 30 500 lb., for the vertical at their point of meeting 3 600 lb., for the counter of the middle panel 1 000 lb., for the diagonal of the adjacent panel 12 400 lb. The unit stress taken for tension members is 10 000 lb. and for compression members is 7 000 lb. Design from standard rolled forms the members that meet at this panel point. (Make close estimates of cross-sections that are not readily computed).

3. Calculate the weights of the bridge members you have designed in answer to the above question, if the metal weighs 492 lb. per cu. ft.

4. Make neat detail drawings showing your method of arranging and joining the above bridge members at the panel point.

(2 Sheets) Last Sheet.

STATE OF NEW YORK—STATE CIVIL SERVICE COMMISSION.

Examination for Junior Bridge Draftsman.

5. Make drawings showing the details for the portal bracing for a highway bridge of the through Pratt type, span 105 ft., depth 27 ft., width between trusses 18 ft.

6. Design a timber truss for a highway span of 30 ft., showing method of its construction.

7. A plate girder is to have a span of 60 ft. and depth of 3.5 ft. The maximum required flange section is 24 sq. in. and the maximum required web section is 20 sq. in. The girder is to be designed in five panels. Make plan, elevation and section drawings, showing method of building up the girder, stiffening it, etc.

TRACER.

Minimum age, 18 years. Usual salary, \$50 to \$75 a month. The examination consists of practical questions and exercises in inking in drawings, making tracings and copies of drawings to scale.

SPECIMEN QUESTIONS.

1. Ink in the drawing attached.

2. Letter, in some suitable style, the following title to the drawing: "Design for a Railroad Arch Culvert."

3. Combine Figs. 1, 2 and 3 into one drawing to the scale 1 in. = 40 ft.

4. Trace Fig. 4 and ink in your tracing.

(2 Sheets) Sheet No. 1.

STATE OF NEW YORK—STATE CIVIL SERVICE COMMISSION.

Examination for Tracer.

Directions: Answer questions 1 to 3 on one sheet of drafting paper, questions 4 to 6 on another sheet as furnished you. Time allowed for the whole examination, 6 hours.

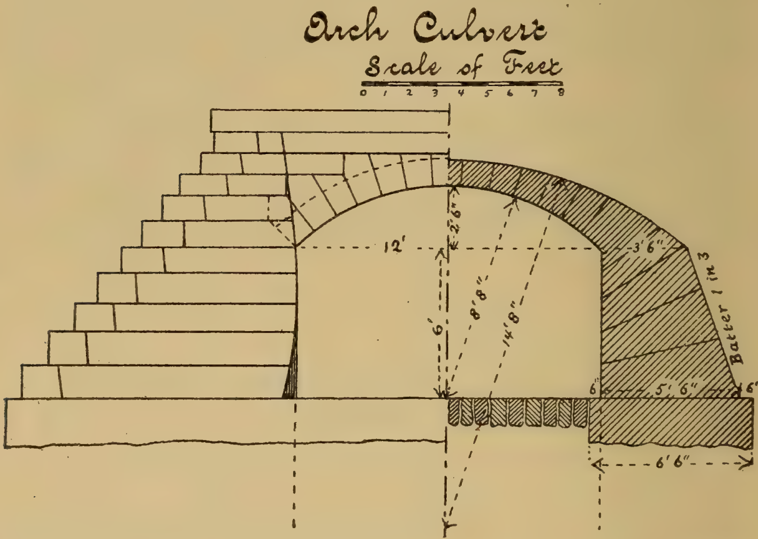
1-2. By the use of pencil, compass and straight-edge only, construct:

(*a*) A line perpendicular to a given line at its extremity.

(*b*) An arc of a circle passing through two points on a horizontal line, 2 in. apart, and a third point 1 in. above the line and to the right of the other points. Do not erase construction lines.

3. Make a perspective drawing of a cube, 2 in. high, placed below and to the left of the eye of the observer.

4-6. Copy the following drawing of an arch-culvert to the scale 1 in. equals 4 ft. and ink in your drawing.

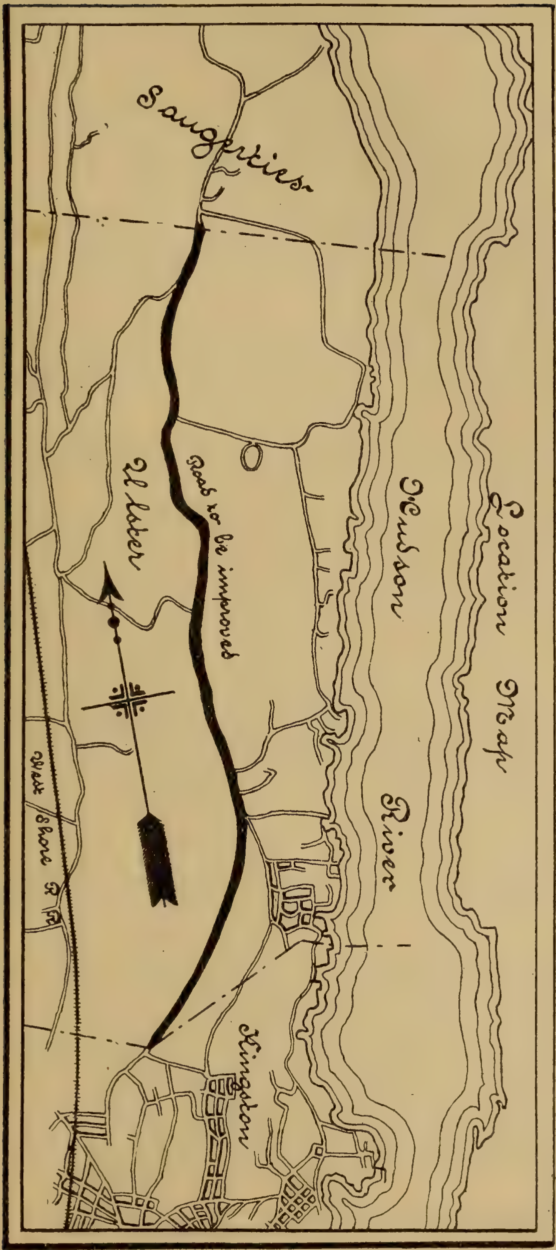


(2 Sheets) Last Sheet.

STATE OF NEW YORK—STATE CIVIL SERVICE COMMISSION.

Examination for Tracer.

7-10. On the sheet of tracing-paper furnished you, trace the map and ink it in so that blue-prints may be made from your tracing. In place of the "round-writing" used, letter your map in some other suitable style of free-hand lettering that you can do neatly and rapidly.


Location Map
Saugerties
Ulster
Road to be improved
Hudson
River
Kingston
West Shore R.R.

GENERAL INSPECTOR OF STREETS AND ROADS.

Technical.

1. In the selection of the kind of covering to be used for a street (whether granite block, asphalt or macadam), state the considerations or conditions that decide in each case.

2. As a rule, which do you think preferable, granite block or trap block pavement (of same shaped blocks), and why?

3. What results may there be from lack of care in preparing the ground surface for a pavement?

4. (*a*) Under what conditions should you think it necessary that a highway should be underdrained? (*b*) How should such a job be done?

5. State every defect to be looked for in the inspection of a lot of granite blocks.

6. Are defects ever found in concrete foundations for pavements, and if so, what are they?

7. State every defect to be looked for in the work of setting granite blocks; in other words, how would you inspect such a pavement?

8. In the work of refilling a trench cut for pipe-laying in a street, is it possible to do it so as to prevent all probability of settlement? If so, how should the men be distributed in the trench?

9. How would you make a quick test of cement to satisfy yourself that it is in good condition to use?

10. (*a*) In what way does wear show itself on a macadam pavement? (*b*) What are the causes of "raveling" of such pavements? (*c*) How can this largely be prevented?

11. (*a*) At what temperature should asphalt pavements be laid? (*b*) What are the results of a departure from this rule?

12. (*a*) Where (that is, in what part of a street) does water have the greatest effect upon an asphalt street surface? (*b*) Why is this the case?

13. In order to get the firmest adhesion of the asphalt to the surface below, either in new work or in making repairs, what are the essentials?

14-15. Write a complete report on the condition of three streets of considerable length which have been in use for some time, one

paved with granite blocks, one paved with asphalt, and one with macadam, giving your recommendations in each case.

INSPECTOR OF PUBLIC WORKS.

Salary, $5 per day when employed.

Open to men only. Time allowed, 6 hours. Subjects of examination and relative weights: Practical questions on materials, construction and inspection, 6; experience and personal qualifications, 4.

SPECIMEN QUESTIONS.

Practical Questions.

1. What difference should be observed between concrete construction for water-tight retaining walls and for ordinary dry foundations?

2. Name all the ways you can suggest of slighting cement masonry.

3. What are the common defects of stone and how discovered?

4. In what cases would you advise the use of grout rather than a full bed of mortar in building stonework?

5. Give the essential points in a first-class job of brickwork in cement, including materials and workmanship.

6. Describe some simple expedients to cheapen quicksand excavation.

7. Describe the construction of the cheapest safe coffer-dam, subject to a head of 12 ft. of water and extending between impervious banks 100 ft. apart.

8. Describe circumstances under which wheelbarrow excavation is the most economical method of handling earth. Same for casting with shovels; handling with carts; handling with cars.

9. Suppose, in excavating for the foundations of a bridge abutment or a lock-wall, that the rock, which was thought to be practically level at a certain depth, is found to fall away rapidly over a part of the foundation; what would you require of the contractor?

10. Does it require more or less earth than that in a given cutting to make an embankment of the same size? How is this provided for in making the embankment?

11. In building a canal, suppose the bottom to be but little below the natural surface; state under this condition every precaution that should be taken or may be necessary to prevent seepage at the junction of the bank with the ground and to insure the stability of the bank.

12. Describe the materials best fitted for puddling, and how they should be used in building a bank to insure imperviousness to the passage of water.

13. What are shakes? checks? What is sapwood, and how told? What is meant by brash timber, and how told?

14. What kinds of timber last best in wet places?

15. Where round drift-bolts are to be used, as in crib-work, etc., state the requirements to be observed in boring for, driving them, etc., to get the strongest hold in the timber.

16. State all the defects you would look for in piles to be used on an important work.

17. (*a*) How would you determine that a pile has been driven to a bearing? (*b*) How would this be affected by piles brooming at the top, and what is the remedy? (*c*) Which is the most effective method of driving, by frequent blows with small fall of ram, or slow blows with a greater fall?

18. How should iron-work be prepared for repainting and what materials and method of application will give the most permanent coating?

SPECIAL EXAMINATIONS.

There are occasional special examinations for positions in which vacancies are of infrequent occurrence and for which examinations are held only when vacancies occur. As to such examinations no detailed information can ordinarily be given in advance of the advertisement of examination. For most of these positions the examination consists entirely of questions upon the duties of the position, the technical knowledge required for their performance, and the experience, education, special training and personal qualifications of candidates. A partial list of such examinations held in the past is given below. *No specimen questions for such examinations can be furnished,* nor will the subjects of examination and relative weights necessarily be the same in future examinations of similar character, as the Commission will be governed by the immediate needs of the service at the time the examinations are called.

FOREMAN OF EARTH BORINGS.

$3.50 to $5 a day.

Appointees will have charge of parties operating "Wash drills," and must have had experience in such work. Candidates are not required to appear at any place for examination, but will be rated on their experience, education and personal qualifications as shown by their sworn statements, and by the answers to inquiries made by the Commission of their former employers and others acquainted with their experience and qualifications.

FOREMAN OF ROCK BORINGS.

$3.50 to $5 a day.

Appointees will have charge of parties operating "Diamond core drills" or "Davis calyx chilled shot drills," and must have had experience in such work. Candidates are not required to appear at any place for examination, but will be rated on their experience, education and personal qualifications as above.

FOREMAN OF PUBLIC WORKS.

Open to men only. Compensation, $2.50 per day and upwards when employed. Candidates must have had thorough practical experience as foremen or in charge of men upon public works or other engineering constructions. Subjects of examination and relative weights: Practical questions on methods of construction and the employment and handling of men, 5; experience, 5.

INSPECTOR GRADE CROSSINGS BUREAU, STATE RAILROAD COMMISSION.

$1 500.

The examination relates entirely to the work of the bureau, including the laws relating thereto, methods of procedure and construction, and considerations affecting the work, and to the experience and personal qualifications of candidates.

INSPECTOR OF HIGHWAY WORK.

$3.50 to $4.50 a day when employed.

Subjects of examination and relative weights: Practical questions on materials, construction and inspection of highway work, 6; experience and personal qualifications, 4.

MECHANICAL ENGINEER AND DRAFTSMAN.

$1 500 to $1 800.

Candidates should be thoroughly familiar with the calculations and design of all kinds of shafting, gearing, chains, cables, pillow blocks, etc., especially with the design of such machinery as is used on swing and lift bridges, mechanical locks, etc. Candidates must have at least five years' practical experience in drafting, designing and constructing this class of work. Subjects of examination and relative weights: Practical and theoretical questions on proportioning machinery as above outlined, 6; experience, education and personal qualifications, 4. For part of the examination candidates may use tables and books of reference as desired.

RESIDENT ENGINEER.

$2 400 a year.

Applicants must have had at least five years' practical experience in civil engineering work, three years of which must have been in responsible charge of work. Candidates will not be required to appear at any place for examination. Subjects of examination and relative weights: Experience, education and personal qualifications rated upon the candidate's detailed statements and upon the answers to inquiries by the Commission from their previous employers and superiors, 5; two theses—a report upon some work of importance carried out under the charge of the candidate, and a discussion of some assigned topic relating to the problems to be handled in the construction of the proposed barge canal in this state, 5. The theses are to be written and submitted by the candidate in accordance with specifications and instructions issued by the Commission.

CIVIL SERVICE OF THE CITY OF BUFFALO.

Instructions to Applicants.

1. All applications by those desiring to render services, within schedule "B," except in Police and Fire Departments, of the rules and regulations prescribed for entering the Civil Service of the City of Buffalo, must be addressed to the "Secretary of the Buffalo Civil Service Commission, Buffalo, N. Y."

2. All such applications must be made under oath, and must state the following facts:

That the applicant is above the age of 21 years, and under 60 years of age; that he is a citizen of the United States and has resided *continuously in Buffalo for the last three years preceding his application;* the street and number of his residence and his post-office address; his age, date and place of birth; the nature of his education; his business training and experience, and his business or employment and residence for the last previous five years; whether he has ever been in official service before, and if so, when and where; and whether he has ever been discharged therefrom, and if so, the reason therefor; whether he has been honorably discharged from military or naval service of the United States, as soldier, sailor or marine during the late Civil War, in which case the discharge, or a duly authenticated copy thereof, shall be submitted with the application; that he is free from any disease or physical defect which might impair his ability to render good and faithful service to the City of Buffalo.

3. The application must contain the certificates of not less than three and not more than five reputable citizens of Buffalo that they, individually, have been personally acquainted with the applicant for at least one year and believe him to be of good moral character, of temperate and industrious habits, and in all respects fit for the service he wishes to enter, and that each such citizen is willing to answer such detailed questions as may be addressed to him by the Commission in relation thereto, and that such certificate should be published for public information.

The applicant should also state whether the application is limited to any particular office or offices in the service. All applications must be in handwriting of applicant.

4. No recommendations or certificates besides those provided for on the blanks will be received, and no additional recommendations can be of any use in securing an appointment.

5. The applicant will be notified of the first examination which he may attend after his application is received. He should give notice of any change of residence.

6. A failure to properly fill the blanks, or to send satisfactory certificates, will cause the application paper to be returned for correction. Applications showing that the applicant lacks the qualifications as to age, health, etc., will be rejected.

7. Applicants may be notified of the result of examinations; when appointed they will be notified of their appointment by the appointing officer.

8. Priority of the date in examination will give no advantage; appointments are made from those standing highest on the eligible list in the order of their standing.

9. No person whose general average standing is less than 75 will be entered on the eligible list.

10. Each subject is marked upon a scale of 100, which represents the maximum possible attainment.

11. Every false statement knowingly made by any person in his application for examination, and every connivance by him at any false statement made in any certificate which may accompany his application, or wilful complicity in any fraud designed to improve his standing upon examination, any physical disability of the applicant which would render him unfit to perform the duties of the position to which he seeks appointment; his being addicted to the habitual use of intoxicating beverages to excess, or his being guilty of a crime, or infamous or notoriously disgraceful conduct, shall be good cause for refusing such person any examination or any rating upon an examination, or for striking his name from any eligible list, or for the removal of such person from any position to which he may have been appointed.

All appointments are first made for a probationary term of three months; if not permanently appointed then, the applicant shall be ineligible for re-examination for one year.

12. No one dismissed from the service for misconduct can be reexamined for appointment in any capacity in the service within two years from such dismissal.

ENGINEERING STAFF IN THE CITY OF BUFFALO, N. Y.

1 Deputy Engineer Commissioner......	Salary	$3 000	per	annum.
1 Assistant Engineer	"	2 500	"	"
2 Assistant Engineers	"	2 400	"	"
3 " "	"	1 800	"	"
1 Assistant Engineer	"	1 600	"	"
1 " " in charge of street repairs	"	1 500	"	"
8 Transitmen	"	1 200	"	"
12 Rodmen	"	900	"	"
2 Draftsmen	"	1 100	"	"

EXAMINATION FOR ASSISTANT CITY ENGINEER.

Experience Sheet.

March 11th, 1905.

Note.—It is desired that applicants should write freely and fully in answer to the following questions, as great importance will be attached to both technical and practical experience, as shown by this part of the examination.

1. What preparatory school have you attended and how long?

2. Have you completed a course in engineering at a correspondence school?

3. (*a*) What college or technical course did you pursue? (*b*) When and where? (*c*) Did you complete the entire course, and have you a diploma from that institution? (*d*) If so, what degree does it confer?

4. (*a*) Have you ever been in City, State or National employ? (*b*) If so, in what capacity, and on what work?

5. Write a full and complete account of your other engineering employment. Describe the work to which you were assigned, stating your special duties and responsibilities.

Note.—This question is framed with the intention of bringing out the applicant's engineering experience since leaving school or college, *and as it is desired to give full credit for practical accomplishments the applicant will do well to write a full and accurate account of his engineering work.* It is suggested for his assistance, that he begin with his first practical experience, and follow on, year by year, with a narrative of his activities, giving some idea of the magnitude and values of the work in which he has been engaged.

EXAMINATION OF ASSISTANT ENGINEERS.

Technical Sheet No. 1.

1. (*a*) Make a complete cross-section of an asphalt pavement giving dimensions. (*b*) Draw specifications covering excavation (the excavation to be in earth). (*c*) Draw specifications covering the curbing and the setting and draining of the same. (*d*) Draw specifications covering the foundation course. (*e*) Draw specifications covering the spreading and finishing of the asphalt.

2. Make sketch and describe briefly how you would construct a pile foundation for bridge pier where it is necessary to go through 15 ft. of quicksand to reach a solid clay bottom.

3. How would you measure the flow of water over a weir?

EXAMINATION FOR ASSISTANT ENGINEERS.

Technical Sheet No. 2.

4. In a stand-pipe 110 ft. high, filled to within 15 ft. $10\frac{1}{2}$ in. from the top, what is the pressure, in pounds, at the base?

5. (*a*) Design a 4-ft. brick sewer. In your design show a cross-section, with a house connection. Also a manhole showing the sewer passing through it. (*b*) State briefly the essential things to be looked out for in the construction of your sewer. (*c*) Your sewer is 4 000 ft. long and averages 12 ft. below the surface, and rock excavation begins 300 ft. from one end and is 7 ft. thick at the other end. Space your manholes 500 ft. apart with one at each end. Make a preliminary estimate of cost, including manholes, but not including any house connections.

EXAMINATION FOR TRANSITMAN.

Held April 8th, 1905.

1. A pier is 4 by 15 ft. on the base and 16 ft. high, and has a batter of $\frac{1}{2}$ in. to the foot. Find the number of cu. yds. of masonry, the total weight, at 150 lb. per cu. ft., and the pressure per square foot on the base.

2. Make up a typical transit-book page, notes to show one angle in the center line, two cross-streets, curb lines, a flat, store, residence with iron fence, a stone monument, double-track trolley line in one of the intersecting streets.

3. Lay out a $1\frac{1}{2}°$ curve with a deflection angle of 4° 27′, the plus of your P. C. being 16 + 71.4.

4. If you were called upon to run in 400 ft. of sewer grade, how would you do it with a transit that did not have an attached level?

5. You want to take soundings in Niagara River, using a base line on shore. How would you arrange your instruments on shore? Give method of procedure.

6. A plot of ground is 600 ft. square and has an interior point 11 ft. higher than the elevations at the corners, which elevations are the same. How would you make a contour survey of it for a topographical map?

7. Make plot of map showing necessary elevations and plot 2-ft. contours.

8. Starting from a bench, elevation of which is 756.73, your rod reads 1.42 and rods on center-line stations are 0.78, 3.41, 7.03, 9.56,

11.87 and on a T. P. 12.12. On new set-up they are on T. P. 2.31 and on new stations 3.01, 4.55, 0.77, 9.13 and 12.97. You have a 2% down grade with grade elevation at Station 1 of 748.16. Make a page of level notes, giving cuts and fills at stations.

EXAMINATION FOR RODMAN.

Experience Sheet.

Note.—It is desired that applicants should write freely and fully in answer to the following questions, as great importance will be attached to both technical and practical experience, as shown by this part of the examination.

1. What schools have you attended and for what period of time?

2. (*a*) What college or technical course did you pursue? (*b*) When and where? (*c*) Did you complete the entire course, and have you a diploma for that institution? (*d*) If so, what degree does it confer?

3. (*a*) Have you ever been in City, State or National employ? (*b*) If so, in what capacity, and on what work?

4. Write a full and complete account of your other engineering employment. Describe the work to which you were assigned, stating your special duties and responsibilities.

This question is framed with the intention of bringing out the applicant's engineering experience since leaving school or college, and as it is desired to give full credit for practical accomplishments the applicant will do well to write a full and accurate account of his engineering work. It is suggested for his assistance that he begin with his first practical experience, and follow on, year by year, with a narrative of his activities, giving some idea of the magnitude and values of the work in which he has been engaged.

EXAMINATION FOR CHAINMAN.

Technical Sheet.

1. How long is a Gunter's chain?

2. Explain the use of eleven pins.

3. Explain how you would chain on a slope steep enough to make it necessary to break chain.

4. Describe the method of locating a point by intersections.

5. How would you lay out a right angle with a chain?

6. In using a steel tape, 100 ft. long, with the last foot graduated in tenths, describe how the two chainmen would determine

and read the plus of a station several hundred feet from the starting point.

7. State the proper way to hold the flag or transit rod.

8. If you were sent out to measure up the finished portion of work on a paving contract, how would you do it if the street were hilly?

9. Describe the method of making a chain survey of a six-sided field.

10. A house stands on the line in a chain survey, how would you chain past it?

11. On account of a rise of ground neither end of a line is visible from the other. Describe the first thing to be done in order to get the measurement.

12. A reservoir site has two parallel sides, and two right angles. (*a*) Describe how you would make a complete chain survey. (*b*) How would you calculate the area?

13. A rectangular city block contains 2.324 acres and is twice as long as it is wide. Give the dimensions.

14. How many square feet of land are there in a street 4 rods wide and $1\frac{3}{4}$ miles long?

15. How many cubic yards of sand under a stone pavement, 30 ft. wide and 2 740 ft. long, the sand being 14 in. deep?

EXAMINATION FOR ROD AND AXEMEN.

HELD JUNE 23D, 1904.

1. What is the length of a Gunter's chain?

2. If a tape is divided into feet and tenths, how many tenths will there be in $48\frac{1}{2}$ ft.?

3. Reduce 262° 44′ 18″ to seconds.

4. Find the capacity in cubic feet of a box of which the inner dimensions are: Length, 25 in.; breadth, 17 in., and depth, $11\frac{1}{2}$ in.

5. What is a transit line?

6. What is land surveying?

7. State in a general way the use of a level.

8. State in a general way the use of a leveling rod.

9. What is a bench-mark?

CIVIL SERVICE OF THE STATE OF MASSACHUSETTS AND THE CITY OF BOSTON.

Instructions to Applicants and Eligibles.

A person desiring to be examined for a position in the classified service should file an application on the prescribed blank, and a form for that purpose can be obtained at the office of the commissioners, room 152, State House, Boston, or of the secretary of the local board of examiners in the city where he lives.

Applications for the service of the Commonwealth and of the city of Boston should be filed in the commissioners' office, Boston; if for service in any city other than Boston they should be filed with the secretary of the board of civil service examiners in such city.

Applications will be received at any time, and notice of the time and place of examination will be seasonably sent to each applicant. If unable to attend the first examination after applying, the applicant will, upon satisfactory explanation, be notified to attend the next examination.

Non-competitive examinations are not given when it is practicable to establish an eligible list by competition, and they are never held at the request of an applicant.

The commissioners cannot furnish information as to the course of preparation which applicants should follow (except as shown by the specimen examination papers printed in their report), nor can they answer inquiries in relation to cases which are not before them for decision, or decide, except in the cases of actual applicants, questions respecting the application of the rules. Particular answers cannot be given to inquiries which are answered herein, directly or by implication.

Notice will be sent by mail to each examined applicant of the result of his examination as soon after the examination as it is practicable to do so.

The names of persons who have passed the required examination will remain on the eligible list two years from the date of their certificate, unless dropped therefrom after certification three times, or removed from said list for cause.

Applicants for clerical service whose names have been placed on the eligible list in Class 2 of Schedule A may also, *upon request in writing,* have their names placed on the eligible list for positions in Class 1 of Schedule A, with the same standing.

Applicants for clerical service in the departments of the Commonwealth whose names have been placed on the eligible list may, *upon request in writing,* have their papers marked by the local board of examiners of the city in which they reside, and their names placed on the eligible list for service in the departments of such city, and *vice versa.*

Persons whose names have been placed on the eligible list in Class 1 of Schedule B (prison service), and who have been certified for appointment, will be subjected to a physical examination if the appointing officer so requests.

The relative standing of any applicant as compared with that of others on the same eligible list may be changed by the addition of names of persons who have obtained higher standing at some more recent examination, and the time of the examination is not considered in making certifications.

Eligibles are certified in the order of their grade, and nothing can help and nothing can hinder their certification for appointment in the order of eligibility as prescribed by the civil service rules.

The commissioners are unable to answer inquiries as to vacancies in the service, salaries, prospects of certification, appointment or promotion. They know nothing of vacancies until requested to certify names for filling them, and it can only be generally said that the highest mark possible is 100, the lowest which gives eligibility is 65, and that the nearer the applicant's mark is to 100 the more likely it is that his name will be reached for certification. It is wholly uncertain, therefore, when an applicant's name may be reached for certification, and it is useless to speculate on what his chances may be.

Applicants will save the commissioners and themselves time and trouble by carefully reading the foregoing and preserving it for reference.

DIVISIONS OF THE CIVIL ENGINEERING FORCE.

Division A, or rodmen: To include chainmen, rodmen, and all assistants under whatever designation, except draftsmen, whose maximum pay does not exceed the rate of $800 per annum.

Division B, or instrument men: To include transitmen, levellers and all assistants under whatever designation, except those covered by divisions A and E, and whose maximum pay does not exceed the rate of $1 100 per annum.

Division C, or assistant engineers (junior grade): To include engineers and surveyors in responsible charge of work and engineers in charge of designing whose maximum pay does not exceed the rate of $1 600 per annum.

Division D, or assistant engineers: To include all engineers whose pay exceeds the rate of $1 600 per annum.

Division E,* or draftsmen (junior grade): To include all assistants whose duties are chiefly those of drafting and whose rate of pay does not exceed $800 per annum.

Division F, or draftsmen (senior grade): To include all assistants whose duties are chiefly those of drafting and whose pay is at the rate of over $800 and does not exceed $1 300 per annum.

SCHEDULE B, CLASS 12, DIVISION A* (RODMAN).

Handwriting; shown by copying printed matter.

Spelling; twenty words, announced by one of the examiners.

Education and experience.

The answers to the questions on this sheet will be marked under the heads of Education and Experience. *Any false statement made by the applicant in answering these questions will be regarded as good cause for excluding him from the eligible list, or for removal or discharge during probation or thereafter.*

What is the date of your birth?

State what grammar school, high school, technical school or college you have attended, the dates and length of attendance, the studies pursued and diplomas taken. State any other facts regarding your education which you think may be of service to the examiners.

Have you had any practical experience in the duties of the position for which you apply? If you have, state the particular position or positions you have held; the nature of your duties in each case; where, when, how long and under whom (giving accurately the name and address) you have been so employed.

Are you employed at present? If you are, give the name and address of your employer, state the nature of your duties and the length of time you have held this position. If you are not employed, state how long you have been without employment and the cause for which you last ceased work.

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* The examination for division A and for division E will occupy one day each. The examinations for the other divisions will occupy two days each.

PREVIOUS EXAMINATION PAPERS.

RODMAN.

Arithmetic.

Including common and decimal fractions, percentage, square root, mensuration of rectangular surfaces and solids.

Sample Questions.

1. Add 467 ft. $8\frac{1}{2}$ in., 27 ft. $9\frac{7}{8}$ in., 510 ft. $4\frac{1}{8}$ in., and 102 ft. $6\frac{5}{8}$ in., and from the sum subtract 299.52 ft., giving the answer to the nearest eighth of an inch.

2. Multiply two hundred fifty-seven ten-thousandths by forty-nine thousandths.

3. Divide 2 880 by .0036.

4. Add $\frac{10}{11}$, $\frac{123}{125}$ and $\frac{53}{55}$, and reduce the sum to a decimal fraction carried to five places of decimals.

5. A dry brick weighing 4 lb. 6 oz. was immersed in water for twenty-four hours, at the end of which time it was found to weigh 5 lb. $0\frac{1}{2}$ oz.; what per cent. of its own weight was absorbed?

6. A square plot of ground contains 108 900 sq. ft.; what is the length of a side?

7. A rectangular piece of land, 210 ft. 3 in. long and 50 ft. 9 in. wide, has a ditch 6 ft. wide and 4 ft. deep, which was dug inside the boundary lines, said lines being the outer edge of the ditch. How many cubic yards of material were removed from the ditch?

Algebra.

To and including the solution of simultaneous equations of the second degree.

Sample Questions.

1. Multiply $\left(x^2 - \frac{x}{3} + \frac{1}{4}\right)$ by $\left(\frac{x}{2} + \frac{1}{4}\right)$.

2. Divide $256\, a^3\, b\, c^2\, x^3$ by $-16\, a^2\, c\, x^2$.

3. Divide a distance of 1 000 ft. into three parts—A, B and C—such that A shall be 72 ft. longer than B and 100 ft. shorter than C. Solve by algebraic method.

4. Solve the equation $2\sqrt{x} + \frac{2}{\sqrt{x}} = 5$.

5. A rectangular field contains 40 960 sq. ft. If its length were increased by 65 ft. and its breadth by 50 ft., its area would be increased by 26 450 sq. ft. Find the length and breadth of the field.

Geometry.

The applicant will be expected to have such familiarity with the principal theorems of plane and solid geometry as will enable him to solve simple problems dealing with lines, angles, areas and volumes. *Demonstrations of theorems will not be required.*

Sample Questions.

1. One interior angle of a certain triangle contains $43° \; 19' \; 40''$; a second interior angle contains $105° \; 59' \; 20''$; what is the value of the remaining angle?

2. Choose any three points on paper, and by aid of a sketch explain how, by geometrical construction, you would find the center of a circle passing through them.

3. What is the length of the circumference of a circle which would enclose an area of 5 000 sq. ft.? $\pi = 3.1416$.

4. If a field have two parallel sides, one of them 356 ft. long and the other 407 ft. long, the perpendicular distance between them being 96.5 ft., what is the area of the field?

5. A stone in the form of a pyramid 3 ft. high, with its base a square 30 in. on a side, will weigh how much, assuming 150 lb. weight to the cubic foot?

Duties.

Questions relating to the construction and use of rods, tapes, verniers and other implements and devices. Details of the work of rodmen in the field and office. Definitions of technical terms.

Tracing.

Tracing-cloth and a plan or a drawing of some engineering structure are furnished the applicant, who will be required to make a tracing in India ink.

SCHEDULE B, CLASS 12, DIVISION B (INSTRUMENT-MAN).

Handwriting.
Spelling.
Education and experience.
} Same as Division A.

Algebra.

To and including the solution of simultaneous equations of the second degree.

Sample Questions.

1. Simplify, as far as possible, the expression $\dfrac{x - 1 - \dfrac{12}{x+3}}{x - 5 + \dfrac{12}{x+3}}$

2. Solve the equation $\left(\dfrac{a}{b} + \dfrac{b}{a}\right)x - \left(\dfrac{a}{b} - \dfrac{b}{a}\right) + 2x = a.$

3. The circumference of the hind-wheel of a carriage is greater by 4 ft. than that of the fore-wheel. In traveling 1 200 yd., the fore-wheel makes 75 revolutions more than the hind-wheel. Find the circumference of each wheel.

4. A man has two square lots of unequal size, together containing 15 025 sq. ft. If the lots were contiguous, it would require 530 ft. of fence to embrace them in a single enclosure of six sides. Find the area of each lot.

5. Solve, for either x or y, the simultaneous equations: $\begin{cases} x^2 + 3y^2 = 28 \\ x^2 + 2y^2 + xy = 16. \end{cases}$

Geometry.

The applicant will be expected to have such familiarity with the principal theorems of plane and solid geometry as will enable him to solve simple problems dealing with lines, angles, areas and volumes. *Demonstrations of theorems will not be required.*

Sample Questions.

1. The altitudes of two equilateral triangles are respectively as 3 to 4. Find the ratio of their areas, and give your reasoning.

2. Show how, by geometrical construction, you would divide a given straight line into any required number of equal parts. Give the reasoning upon which you base your construction.

3. Find the length of the perimeter of an equilateral triangle which would enclose one acre.

4. A metal cylinder 5 ft. long and 8 in. in diameter is turned down in a lathe to a diameter of 6 in. Find the total weight of metal removed, assuming 450 lb. per cu. ft.

5. A cone measures 32 ft. around the base, and the length of its slope is 8 ft. Find the number of cubic yards it contains.

TRIGONOMETRY.

Plane trigonometry,—trigonometrical functions, properties of logarithms and use of logarithmic table, solution of triangles, either right or oblique, by either natural functions or logarithms.

SAMPLE QUESTIONS.

1. What do you understand by the cosine of an angle? By the tangent? By the versed sine? The sine of a certain angle is $\frac{1}{3}$; compute its cosine. What is the cosine of 135°?

2. What do you understand by the base of a system of logarithms? What is the base of the common system? In the common system, what is the logarithm of 1? Of 1 000? Of 0.01?

3. Compute by logarithms:

$$\frac{3.7096 \times 286.51 \times 0.2956}{1633.72}; \quad (23.8464)^3; \quad \sqrt[3]{0.0042937}.$$

4. In a right-angled triangle the hypothenuse measures 154 ft., and one of the acute angles 49° 53′. Compute, by natural functions, the lengths of the sides; determine also the area of the triangle.

5. In an oblique triangle, the angle B measures 19° 21′ 40″, the angle A 103° 35′, and the side opposite B 87.36 ft. Compute, by logarithms, one of the remaining sides.

DUTIES.

Questions relating to the details of the work of the second man in a surveying party, in the field and office, including the construction, adjustment, care and use of the transit and level; compass and stadia surveying; details of surveying and leveling, keeping field notes, measuring and counting earth work. Definition of technical terms.

PLOTTING.

Plotting a survey by co-ordinates from field notes, inking-in plot and lettering a title.

Sample Question.

Plot accurately on a scale of 20 ft. to an inch, the survey of a lot of land given in the following notes:

Station.	Bearing.	Distance.
1.	N. 35° 0′ E.	108.00 feet.
2.	N. 83° 30′ E.	51.60 "
3.	S. 57° 0′ E.	88.80 "
4.	S. 34° 15′ W.	142.00 "
5.	S. 56° 30′ W.	129.20 "

Ink in the plot, mark the bearing and length of each side, and letter the following title, making your own arrangement: "Plan of land belonging to John Smith, December, 1897. Scale, 20 ft. to an inch." (Arrange and space all letters, and finish enough in each line to show your skill.)

SCHEDULE B, CLASS 12, DIVISION C (ASSISTANT ENGINEER, JUNIOR GRADE).

Education and Experience.

Same as Division A.

Algebra.

To and including the solution of simultaneous equations of the second degree.

Sample Questions.

1. Find, in as simple form as possible, the value of

$$\left(\frac{2}{3\,y^2} - \frac{2}{x\,y} + \frac{3}{2\,x^2}\right) \div \left(\frac{2}{3\,y^2} - \frac{3}{2\,x^2}\right).$$

2. Increase the length of a given rectangle 2 ft., and its width 1 ft., and its area is increased 12 sq. ft. On the other hand, diminish its length 3 ft., and its width 2 ft., and its area is diminished 11 sq. ft. What is the perimeter of the rectangle?

3. Francis' formula for the discharge over suppressed weirs is $Q = 3.33\, l\, h^{\frac{3}{2}}$, in which, if l and h are in feet, Q is in cubic feet per sec. If h be 0.324 ft., what value of l will correspond to 5.37 cu. ft. per second for Q?

4. A boat's crew rowed down stream 7 miles and back in 3 hours 20 minutes. The velocity of the current was 2 miles per hour. How many miles per hour would the crew make in still water?

5. Two loans, together amounting to $45 000, are made at different rates of interest, but the amounts borrowed are such that the respective annual interest payments are equal. If the first loan were to be charged the second's rate of interest, its annual payment would be $800; and if the second loan were to be charged the first's rate of interest, its annual payment would be $1 250. Find the respective rates of interest.

Geometry.

The applicant will be expected to have such familiarity with the principal theorems of plane and solid geometry as will enable him to solve simple problems dealing with lines, angles, areas, and volumes. *Demonstrations of theorems will not be required.*

Sample Questions.

1. Explain, by reference to a sketch, how you would divide a line that is 26 in. long into three parts proportional to the numbers 2, $\frac{3}{4}$, $\frac{1}{2}$. Compute also the lengths of the respective parts.

2. A hexagonal bar of steel, 10 ft. 3 in. long, measures 12 in. around the perimeter of a right section. What is the weight of the bar, at 490 lb. per cu. ft.?

3. A trapezoidal lot of land, 120 ft. in length, measured perpendicularly between its parallel ends, tapers uniformly and equally on both sides from a width of 24 ft. at one end to 14 ft. at the other end. Where should it be cut transversely, that is, parallel to the ends, so as to make two pieces of equal area?

4. The base of a pyramid contains 144 sq. ft. A plane parallel to the base and 4 ft. from the vertex cuts a section containing 64 sq. ft. What is the height of the pyramid?

5. A hollow cylinder 4 ft. in diameter and 15 ft. long, lying upon its side, is filled with water until the latter touches two-thirds of the circumference, at which time it is also within 1 ft. of the top. How much water does the cylinder then contain?

Trigonometry.

Plane trigonometry—trigonometrical functions, properties of logarithms and use of logarithmic table, solution of triangles, either right or oblique, by either natural functions or logarithms.

Sample Questions.

1. The value of the sine of a certain angle is $\frac{12}{13}$. Without using tables, find the value of cosine, tangent, cotangent, secant and cosecant, and show clearly your method.

2. Three times the sine of a certain angle is equal to twice the square of the cosine of the same angle. What is the angle?

3. By logarithms obtain the value of the following expression:

$$\frac{(0.68291)^{\frac{5}{2}} \times \sqrt{5.9546} \times \sqrt[3]{61.2}}{\sqrt[5]{298.543}}$$

4. Two tangents to a circular curve of 3 000 ft. radius intersect so as to include an interior angle of 157° 8′. Find the length of either tangent from point of contact with curve to point of intersection, using natural functions.

5. A distance $A\ B$ across a stream is to be determined. A base line $A\ C$, 200 ft. long, is measured off on one bank, sights are taken from each end of it to B, and the angles which the lines of sight make with the base are measured, A being 104° 53′ and C 58° 11′. Compute the distance $A\ B$, using logarithms.

DUTIES.

Questions relating to the work of the head of an engineering field party, including the special work of surveying in cities, giving lines and grades for construction, measuring and estimating earth, rock and quantities in engineering structures; definition of technical terms; surveying problems.

ENGINEERING THEORY.

Elementary principles of mechanics, hydrostatics and hydraulics, and their application to simple problems. Problems in surveying.

SAMPLE QUESTIONS.

(Applicants are required to answer but three questions.)

1. The notes of a survey and the calculated latitudes and departures are as follows:

Stations.	Bearings.	Distances.	Latitudes.	Departures.
1.	N. 30° 0′ E.	328.68	284.64	164.34
2.	N. 57° 45′ E.	306.90	163.78	259.54
3.	S. 39° 30′ E.	396.00	305.58	251.87
4.	S. 37° 15′ W.	391.38	311.53	236.92
5.	N. 69° 15′ W.	465.96	165.07	435.78

Balance the survey, give the error of closure and calculate the area.

2. Two streets intersect at an angle of 42° 28′. It is desired to ease the acute-angled intersection, making the street boundary a circular curve of 10-ft. radius, tangent to the street lines. Give the area of the land to be taken, and the length of each line bounding it.

3. What should be the cross-section of a yellow pine beam 12 ft. long, supported at both ends, to sustain with safety a center load of 5 000 lb.?

What should be the cross-section if the load is uniformly distributed?

If a beam of the same length is fixed at one end only, and has the same load concentrated at the other, what should be the cross-section?

Assume for all cases an extreme fiber strain of 1 250 lb. per sq. in. The moment of inertia of a rectangle is $\frac{b\,h^3}{12}$.

4. Compute the number of square yards of paving in the roadbed of a section of a curved street 30 ft. wide, the radius of the center line being 175 ft. and the angle at the center being 47°.

5. A rectangular wall 10 ft. high, weighing 140 lb. per cu. ft., would need to be how thick in order to be stable against overturning, if exposed to the pressure of water standing level with its top on one side only?

6. Compute the tension in pounds per square inch in the metal of a water pipe, if the metal be $\frac{1}{2}$ in. thick, the inside diameter of pipe 2 ft., and the water pressure that due to a static head of 207 ft.

7. The diameter of a steam engine cylinder is 9 in., the length of crank 10 in., the number of revolutions per minute 110, and the mean effective pressure of the steam 35 lb. per sq. in. Find the indicated horse-power.

Materials and Methods of Construction.

Properties and characteristics of the various materials used in engineering construction; proper tests to be applied to ascertain their strength and other qualities; methods employed in preparing and placing the materials in the work; definition of technical terms.

The questions which have been given have related to stone and brick masonry, methods of laying and bonding various classes of masonry, and the qualities of the several materials entering into their construction; to the different kinds of hydraulic cements, their strengths and methods of testing; to concrete, the proper proportions of the several ingredients and methods of mixing and depositing under different conditions; to the different kinds of roads and pavements, the materials used and methods of building; to the properties and characteristics of cast iron, wrought iron and steel, to the uses for which each is best adapted, and to their strengths and methods of testing the same. Definition of technical terms in common use in engineering specifications.

SCHEDULE B, CLASS 12, DIVISION D (ASSISTANT ENGINEER, SENIOR GRADE).

Education and Experience.

Same as Division A.

Trigonometry.

Plane trigonometry—trigonometrical functions, properties of logarithms and use of logarithmic table, solution of triangles, either right or oblique, by either natural functions or logarithms.

Sample Questions.

1. The value of the tangent of a certain angle is $\frac{5}{12}$. Without using tables, find the value of sine, cosine, cotangent, secant and cosecant, and show clearly your method.

2. Water runs 42 in. deep in a 48-in. circular conduit. What is the area of the water section?

3. By logarithms obtain the value of the following expression:

$$\frac{(0.68291)^{\frac{3}{2}} \times \sqrt{5.9548} \times \sqrt[3]{61.2}}{\sqrt[5]{288.543}}.$$

4. Two tangents to a circular curve of 2 900 ft. radius intersect so as to include an interior angle of 157° 8′. Find the length of either tangent from point of contact with curve to point of intersection, using natural functions.

5. A distance *A B* across a stream is to be determined. A base line *A C*, 220 ft. long, is measured off on one bank, sights are taken from each end of it to *B*, and the angles which the lines of sight make with the base are measured, *A* being 104° 53′ and *C* 58° 11′. Compute the distance, *A B*, using logarithms.

Engineering Theory.

Same as Division C.

Materials and Methods of Construction.

Same as Division C (*except for surveyors**).

* For surveyors (instead of materials and methods of construction): Advanced surveying. Questions in geodetic, topographic and hydrographic surveying, methods of accurate land surveying and leveling in cities; details of the work of laying out and grading new streets and relocating old streets; evidence of ownership in disputed boundary lines. Surveying problems.

Designing.

This subject requires the applicant to make a complete design of an engineering structure in the particular line of work in which he is engaged, or in which he seeks employment, and to answer pertinent questions as to the actual work of construction. Data to the extent usually available in actual practice will be given, and from these the applicant must make the necessary computations, prepare plans and sketches, showing clearly his design, and write a brief specification of the work to be done, the whole to be in sufficient detail to enable a definite proposal to be made for building the proposed structure.

At the beginning of his second day's work each applicant has been required to announce his choice of some one of the following optional subjects upon which he elected to be examined:

1. Design for a plate-girder bridge.

2. Design for a through-truss highway bridge.

3. Design for a bridge abutment of masonry, with wing walls.

4. Design for a street intersection.

5. Advanced surveying, and surveying problems.

6. Design for the cross-section of a trunk sewer.

7. Design for a system of separate sewers.

8. Questions relating mainly to excavation and embankment; heavy masonry construction in tunnels, aqueducts and walls; water-pipe laying; and the interpretation of drawings. A certain amount of choice has been permitted in the subdivisions of this class.

SCHEDULE B, CLASS 12, DIVISION E (DRAFTSMAN, JUNIOR GRADE).

Handwriting. Spelling. Education. Experience. Arithmetic. Algebra. Geometry. Tracing.	Same as Division A.

Instead of the subject called "Duties," which appears in the rodman's examination, the applicants for this division will be given elementary drawing.

SCHEDULE B, CLASS 12, DIVISION F (DRAFTSMAN, SENIOR GRADE).

Handwriting. Spelling. Education and Experience.	Same as Division A.

Arithmetic.

Including common and decimal fractions, percentage, square root, mensuration of rectangular surfaces and solids.

Sample Questions.

1. Change the following lengths to feet and inches, giving the answers to the nearest eighth of an inch: 12.56 ft.; 6.82 ft.; 4.20 ft.

2. Divide one and six hundred sixteen thousandths by eight ten-thousandths.

3. Add $\frac{11}{14}$, $\frac{3}{10}$ and $\frac{19}{21}$, and from the sum subtract nine thousand one hundred forty-seven hundred-thousandths. *Carry the work to five places of decimals.*

4. Twenty-five thousand ft., board measure, of 2-in. plank were sent from the lumber yard to cover the roadway of a bridge 260 ft. long and 42 ft. wide. What per cent. of the planking was wasted?

Algebra.

To and including the solution of simultaneous equations of the second degree.

Sample Questions.

1. Multiply $\frac{10\,a^3\,y}{9\,bx^2}$ by $\frac{3\,b^4\,x^3}{4\,a^3\,y^2}$.

2. Divide $x^6 - 6\,x^4 + 5\,x^2 - 1$ by $x^3 + 2\,x^2 - x - 1$.

3. There are three numbers. If we add $\frac{1}{2}$ the first to $\frac{1}{3}$ the second plus $\frac{1}{4}$ the third, the sum will be 62. Or $\frac{1}{3}$ the first plus $\frac{1}{4}$ the second plus $\frac{1}{5}$ the third equals 47. Or $\frac{1}{4}$ the first plus $\frac{1}{5}$ the second plus $\frac{1}{6}$ the third equals 38. Find the numbers.

4. Solve the equation $4\,x - \frac{14 - x}{x + 1} = 14.$

5. A rectangular plot of ground is surrounded by a walk 7 ft. wide. The area of the plot and walk is 15 000 sq. ft., and of the walk 3 696 sq. ft. Find the length and breadth of the plot.

Geometry.

The applicant will be expected to have such familiarity with the principal theorems of plane and solid geometry as will enable him to solve simple problems dealing with lines, angles, areas and volumes. *Demonstrations of theorems will not be required.*

Sample Questions.

1. Through the vertex of a right angle a straight line of indefinite length is drawn, lying outside the angle. What is the sum of the two acute angles thereby formed? *Give your reasoning.*

2. If the angle at the vertex of an isosceles triangle is a right angle, what ratio exists between the base and the altitude? *Give your reasoning.*

3. Supposing a tangent drawn to a circle from a given point without; show by a sketch how you would determine the precise point of tangency. *Give the reasons for your method.*

4. The bases of a trapezoid are 32 ft. and 20 ft. respectively. Each of the other sides is 10 ft. Find the area of the trapezoid.

5. A cubic foot of brass is drawn into a wire $\frac{1}{8}$ inch in diameter. Find the length of the wire to the nearest foot. $\pi = 3.1416$.

Trigonometry.

Plane trigonometry—trigonometrical functions, properties of logarithms and use of logarithmic table, solution of triangles, either right or oblique, by either natural functions or logarithms.

Sample Questions.

1. In a triangle $A\ B\ C$ the angle A is 90°; the side $A\,B$ is 4 units long, $A\ C$ 3 units, and $B\ C$ 5 units. State, from inspection of the figure, the value of the cosine of the angle C; the sine of B; the tangent of C; the secant of B.

2. Construct on paper an angle of 53° 14′ by means of its tangent (to be obtained from the tables), and explain your method.

3. Multiply 4978.3 by $(0.2916)^3$ and divide the result by $\sqrt[5]{1.985}$, using logarithms for all the computations.

4. A regular octagon is inscribed in a circle of 8 ft. diameter. Compute the length of a side, using only natural functions for the angles.

5. From a point in the same horizontal plane with the base of a tower, the angle of elevation of its top is 50° 39′; and from a point 100 ft. further away it is 35° 16′. Required the height of the tower.

Duties.

Questions relating to the implements, materials and methods used in making maps and plans. Details of plans, such as lettering titles, coloring and ornamenting; scales, north points, etc.

Methods of duplicating, preserving and cleaning plans, etc.

Tracing.

Same as Division A.

Plotting.

Plotting a survey by co-ordinates from field notes, inking in plot and lettering a title.

Sample Question.

Plot accurately, on a scale of 30 ft. to an inch, the survey of a parcel of land given in the following notes:

Station.	Bearing.	Distance.
1.	N. 48° 30′ E.	213.00 feet.
2.	S. 42° 15′ E.	193.80 "
3.	S. 49° 15′ W.	162.00 "
4.	N. 82° 15′ W.	77.40 "
5.	N. 42° 45′ W.	133.20 "

Locate station one $5\frac{1}{2}$ in. from the bottom of the drawing paper and two inches from the left margin.

Ink-in the plot, mark the bearing and length of each side, draw a north point and letter the following title, making your own arrangement: "Plan of land in Boston belonging to John Smith, March, 1898. Scale, 30 ft. to an inch."

Drawing.

This subject calls for the making of a detailed drawing of an engineering structure, the whole to be finished in India ink and neatly lettered. A rough sketch will be furnished, giving the general dimensions of the structure, and such other data will be supplied as a chief draftsman or designer in actual practice would give to his assistant to enable him to prepare a set of working drawings.

In examinations already held, the applicants have been required to make the drawings of a masonry abutment for a highway bridge.

CIVIL SERVICE OF THE CITY OF NEW ORLEANS, LA.

INSTRUCTIONS TO APPLICANTS.

I. General Instructions.

Candidates for any Civil Service position under the government of the City of New Orleans, should, first of all, carefully read the printed rules of the Board. These will answer many questions, and a careful reading of them will prevent many mistakes. Should any additional information be desired, it may be obtained at the office of the Board, which is always open within legal hours.

2. Persons Who Will Not Be Examined.

No person will be admitted to examination:

(*a*) Who is physically disqualified for the kind of service he seeks;

(*b*) Who habitually uses intoxicating liquors to excess;

(*c*) Who is enlisted in the army or navy.

(*d*) Who has been dismissed from the service of the City of New Orleans for good cause.

3. Obtaining and Filling Out Application Blanks.

No person will be admitted to examination who has not previously filed an application for the particular examination which he seeks on the application blank prescribed by the Board. Each applicant must apply for his own application blank, as it is contrary to the rules of the Board to furnish blanks to one person for the use of another person.

The certificate of vouchers required in the application papers are of the utmost importance. Applicants should seek as vouchers persons who have practically known them in their callings. The certificates of persons of distinction in politics are of weight, only so far as they show real or close knowledge of the candidate, and the Board's action can in no way be biased by the political influence, real or supposititious, of the signers.

Full instructions for the execution of the application will be found on the blank itself, and applicants are cautioned to answer all questions and conform in all respects to the printed instructions. A failure to do this causes delay and annoyance.

Applicants will not be admitted to examinations who have not complied with the requirements of other proper authority in advance. An application will be good for only one kind of examination, and if an applicant desires to take more than one kind of examination he must file a separate application for each kind desired.

In the case of foreign-born citizens proof of citizenship must be furnished. If naturalized, a certificate of naturalization must accompany the application. A foreign-born person who claims that his parents were citizens of the United States at the time of his birth must furnish evidence in support of his claim. A foreign-born citizen who was naturalized by the naturalization of his father or his mother, while he was a minor, must furnish his father's certificate of naturalization, and evidence of his identity as the child of the one whose certificate is furnished. A woman who claims naturalization through marriage to a citizen of the United States must furnish evidence of the husband's citizenship (his certificate being required if he is a naturalized citizen) and evidence of her marriage to him.

An application from a foreign-born person claiming citizenship, but failing to furnish the required proof, will be cancelled. A declaration of intention to become a citizen will not be accepted in lieu of a certificate of naturalization. When naturalization papers are lost a certificate must be procured from the court that issued the naturalization papers, showing the facts in the case.

Persons who have been indicted or convicted of any offense must enclose with their application a statement showing the essential facts of the case.

All applications which show the applicants to be ineligible on any account will be cancelled and retained in the files of the Board. All applications which are defective in their execution and can be corrected by the applicant will be returned for correction, but an application which has been twice returned for correction and is still found to be incomplete will be cancelled.

Applications which have been approved or cancelled, and all examination papers of competitors form a part of the official records of the Board, and cannot, under any circumstances, be returned to the applicants.

4. Period of Eligibility.

The period of eligibility expires January 31st of each calendar year.

5. Record of Standing of Competitors.

A record of standing will be furnished to each person examined, whether he passes or fails to pass.

6. Change of Address.

Applicants and eligibles must keep the Board informed of any change of post-office address. A failure to do so may easily result in the loss of an opportunity for appointment.

7. Waiver of Certification.

An eligible may, upon giving to the Board in writing satisfactory reasons, waive certification without losing his eligibility.

8. Effect of Declining Appointment.

An eligible who declines an appointment tendered him will not again be certified unless he shall request in writing a further certification, stating reasons, which must be satisfactory to the Board for declining the appointment.

No person shall be considered a bona-fide resident of the City of New Orleans for one year prior to his employment.

All the permanent employees of said Board, who are required to be appointed after civil service examination, shall be of good moral character, and bona-fide residents of the City of New Orleans for at least one year prior to their appointment. Said Board shall have power, and it shall be its duty, to demand and require bonds with good and sufficient surety for the faithful performance of their duties from all of its employees who handle money or material, or who fill positions of responsibility.

CIVIL ENGINEERING POSITIONS IN THE OFFICIAL SERVICE.

Tracers, at salaries less than $600 per annum.

Positions involving a knowledge of drafting, at salaries of $600 per annum, or more, and not greater than $1 000 per annum.

Draftsmen, with salaries of $800 per annum, or more, and not more than $1 000 per annum.

Draftsmen, with salaries of $800 per annum, or more, and not more than $1 200 per annum.

Positions involving a knowledge of topographical drafting, with salaries greater than $1 000 per annum.

Positions involving a knowledge of architectural drafting, with salaries greater than $1 000 per annum.

Levelmen.

Rodmen.

Paving Inspectors.

Superintendent of Architecture, Department of Engineers.

Chief Inspector Sewerage System.

Chief Inspector Water Supply System.

Inspectors Sewerage System.

Inspectors Water Supply System.

SPECIMEN EXAMINATION PAPERS.

BUILDING INSPECTORS.

Arithmetic.

1. Multiply $3\frac{3}{5}$ by $41\frac{5}{31}$.

2. Reduce .3125 to 16ths.

3. Bought a number of barrels of lime and used 84% for mortar; there are 32 bbls. left. How many barrels were bought?

4. Find the square root of 611424.

5. If sound travels 6 160 ft. in $5\frac{1}{2}$ sec., how far will it travel in one minute?

Practical and Technical.

1. What is the safe load per square foot on foundations in New Orleans?

2. Describe the best method of building brick foundations?

3. (*a*) What are the best materials to use for concrete, and what are the best proportions for same? (*b*) What is the best method of mixing and laying concrete? (Describe how this is done so as to insure best results if the materials and proportions are all right.)

4. What is done to prevent dampness of the ground from rising in brick walls and what is the best way to do it?

5. Give the names of five (5) of the best high-grade German or American Portland cements?

6. Describe two (2) methods of bonding pressed brick work and state which, in your opinion, is best?

7. Does lumber shrink in length and breadth and thickness, or in only one or more of these dimensions?

8. What is a cantilever beam?

9. Why is it necessary to use traps to the waste-pipe of plumbing fixtures? How are the traps ventilated?

10. How are the plumbing pipes tested to make sure that they are tight?

11. How far apart should laths be placed to insure proper keys for plastering?

12. What number of galvanized iron should be used for an eight (8″) inch ogee gutter?

13. What lap should be given to slates for quarter-pitch roof?

14. The formula for the ultimate strength of pine beams supported at both ends and uniformly loaded is $\frac{4\,R\,b\,d^2}{3\,L}$;

R = modulus of rupture = 7 300 lb.;
b = breadth in inches;
d = depth in inches;
L = length in inches.

What is the breaking load uniformly distributed on a pine beam 6 in. by 8 in. by 12 ft. 0 in. which is supported at both ends? What factor of safety should be used and what is the safe load?

15. What should be the thickness of the walls of each story of a 5-story brick building?

Spelling.

Pavilion	Oriel	Advisable
Chargeable	Collateral	Parallel
Forfeit	Guarantee	Miscellaneous
Negotiable	Promissory	Recommend
Birch	Frieze	Grotesque
Sphinx	Mausoleum	Interstice
Astragal	Unsymmetrically	

GENERAL SUPERINTENDENT, PUBLIC WORKS.

Practical Questions.

1. What are the duties of the General Superintendent of the Public Works Department?

2. Explain what are done with complaints reaching the Department?

3. With what tools does the Department furnish its workmen?

4. What extent of asphalt roadway and contiguous stone pavements has it been found by experience that one man can keep clean?

5. What is the price per day of driver, animal and cart?

6. What improvement on the present style of carts collecting garbage might be proposed for economical and better service?

7. With the present style of carts removing street pilings, is it proper to attempt to remove slush and soft mud at the moment of removal from gutters?

8. What check for proper amount of work for a day's hauling should be applied to the work of a cartman?

9. What new public work now about to be constructed might facilitate the removal of gutter pilings from the front of our city?

10. Would it be possible to have the pilings sell for about the cost of their removal from the gutters and streets?

11. How many feet, board measure, in the following:

7	pcs.	6″ ×	8″ ×	18′
9	"	2″ ×	12″ ×	15′
6	"	3″ ×	9″ ×	12′
3	"	3″ ×	4″ ×	20′
5	"	4″ ×	6″ ×	15′

12. Explain how to obtain the volume or capacity of a cart?

13. How many barrelfuls in a pile of lake shells having a volume of 1 220 cu. ft.?

14. With what kind and size of nails are 3-in. planks fastened?

15. How might economy be exercised concerning the present method of attendance on the turn-bridges in charge of the Department, and state the possible economy in each instance?

Letter Writing.

Write a letter of not less than 150 words concerning the collection and disposal of garbage.

Arithmetic and Mensuration.

1. Add

932576418
4394287
56431979
60356
798795
40019

2. Multiply 7896537
by 8973

3. Divide 239786509
by 799

4. From $\frac{1}{5}$ of $\frac{3}{8}$ of $2\frac{1}{3}$ take $\frac{3}{5}$ of $\frac{1}{6}$.

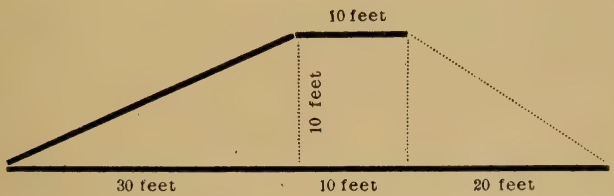
5. What is 17% of \$2 789?

6. If three men can lay 4 000 bricks in two days, how many men can lay 12 000 in 3 days?

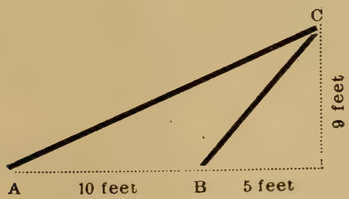
7. If the area of a circle whose radius is 1 ft. equals 3.1416 ft., what is the area of the circle in square yards whose radius is 5 ft.?

8. Find the volume in cubic yards of a right cylinder whose end area is the answer to the preceding question and having a length of 9 ft.

9. If the cross-section of a level is of the following form and dimension, and 105 ft. long, what is its volume in cubic yards?



10. A triangle A B C of the following shape has the dimensions and other measurements relative thereto as marked in feet. Find its area in square feet.



Spelling.

Wharves	Collection	Recede
Barricade	Asphalt	Supervisor
Supersede	Separate	Balance
Rendezvous	Metairie	Avidity
Corrodible	Discussion	Empirical
Fallible	Grievance	Libelous
Nausea	Querulous	

ARCHITECTURAL DRAFTING.

Arithmetic.

1. Multiply $7\frac{1}{8}$ by 26, 126 4-17.

2. Reduce .4226 to 15ths.

3. A man owns $\frac{2}{3}$ of a property; 35% of his share is worth $1 500. What is the value of the property?

4. A note was given on August 5, 1902, and was paid on March 9, 1904. How long did it run? What is the total interest in that time at 6% per annum?

5. What is the square root of 3426201?

Drawing.

The applicant shall copy the accompanying blue-print as neatly and as accurately as possible.

The drawing shall be in pencil (not inked). The following title shall be placed on the drawing:

Example of Roman Doric.

Schedule B 6. No. February 3, 1905.
Architectural Drafting. New Orleans, La.

Letters to be in free-hand and in pencil with Capitals 3-16 in. high and small letters 7-32 in. high.

Geometry and Mensuration.

1. A circular tank measures 6 ft. in diameter, and is 8 ft. 6 in. high; bottom of overflow pipe is six in. (6 in.) from top of tank.

How many pounds of water does the tank contain?

(One gal. of water weighs 8.35 lb., and there are 7.48 gal. of water per cubic foot.)

($\pi = 3.1416$.)

2. What length of stone coping is required for a gable the width of which is 32 ft. and the height $\frac{3}{4}$ of the span?

3. What angle does the minute hand of a clock travel in 10 minutes?

4. A hollow circular cast-iron column has an external diameter of 8 in. and is required to carry a load of 47 120 lb., and should be loaded 4 000 lb. per sq. in. What thickness of the metal ring is required?

5. If brick masonry can carry 10 tons (of 2 000 lb.) per sq. ft., what must be the area of the plate under the same column and resting on masonry?

Letter Writing.

Subject: A description of a beautiful building which the applicant is supposed to have seen, or has seen.

This letter should contain at least 125 words.

Spelling.

Acanthus	Presbytery	Pilaster	Escutcheon
Caryatides	Finial	Stanchion	Crypt
Gargoyle	Andirons	Israelite	Quoin
Corinthian	Chalice	Pinnacles	Triglyph
Medieval	Pargeting	Cantilever	Tympanum

Plain Copy.

Which will also serve as the Test of Penmanship.

The mind of man naturally hates everything that looks like a restraint upon it, and is apt to fancy itself under a sort of confinement, when the sight is pent up in a narrow compass, and shortened on every side by the neighborhood of walls or mountains. On the contrary, a spacious horizon is an image of liberty, where the eye has room to range abroad, to expatiate at large on the immensity of its views, and to lose itself amidst the variety of objects that offer themselves to its observation. Such wide and undetermined prospects are pleasing to the fancy, as the speculations of eternity, or infinitude, are to the understanding.

Spelling.

Accident	Forget	Opposite
Beggar	Gamble	Prepare
Censure	Inquire	Quiet
Collision	Incompetent	Refer
Disobedience	Innocent	Suspect
Disperse	Judicial	Witness
Effect	Market	

CLASS A. SCHEDULE B 8.

Rodmen.

The applicant is required to make an identical copy of the following. Be particular, while so doing, as it is for a test of your penmanship and ability to make copies of communications:

Plain Copy.

Portland cement is made from artificial mixtures of clay and chalk burnt and ground to powder. Natural limestone containing

the requisite proportions of these ingredients is, however, found and used in some localities. The cement derives its name from its similarity, when set, in both hardness and color to Portland stone. It is used where no special haste in construction is to be exercised and where great strength is required.

A good quality of Roman cement is made from natural stone nodules found in clay of the city of London. It is valuable on account of its quick-setting properties, usually becoming hard in 15 minutes. It is much used for tidal work. Roman cement does not admit of storage for long periods.

Arithmetic.

1. Add 79.8336; 234.657; 293.52; 7.8; 1937.54 and 837.4327.

2. Subtract 385.5793 from 395.28.

3. Multiply 3486.345 by 76.58.

4. Divide: 47957813.86 by 837.963.

5. Add $\frac{2}{3}$ of $\frac{7}{9} \times \frac{3}{5}$ to $5\frac{3}{4} \div \frac{4}{5}$.

6. Reduce $\frac{3}{5}$ and $\frac{7}{8}$ to decimals.

7. What is 3% of 1 000 ft.?

8. How many feet and inches in 25 links of a gunthers chain?

9. What is the difference between 4 sq. ft. and 4 ft. square?

10. How many granite blocks, 12 in. by 18 in., will be required to pave a mile of roadway 42 ft. in width?

Mensuration.

1. How many square yards of pavement in the intersection of two sidewalks, one 12 ft. wide and the other 10 ft. wide, less the thickness of steel concrete curbing which is 6 in.?

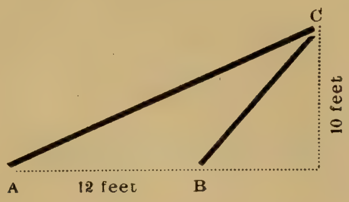
2. How many superficial square yards 6 in. thick can be made from a cubic yard? How many superficial feet 6 in. thick can be made from a cubic yard?

3. A lot is 30 ft. wide by 120 ft. deep and surface is level. If 9 in. fill is fixed at the front line and 20 in. at the rear line, what is the average depth of fill, and how many cubic yards are required to fill the lot?

4. Allow $\frac{1}{3}$ of the yardage of above for settlement and 2 cu. yds. hauled in 3 loads. How many loads will be required to fill the lot so

that when ultimate settlement has taken place, the lot will be at proper grade?

5. Find the area of a scalene triangle *A, B, C,* having the accompanying figure:



SPELLING.

Hatchet	Level	Stall	Version
Stakes	Height	Tyranny	Visible
Distances	Tedious	Totally	Welcome
Weeds	Tenement	Uncivil	Warrant
Bushes	Recreant	Polite	Wriggle

CHICAGO, ILL.

CIVIL SERVICE EXAMINATION QUESTIONS FOR STRUCTURAL IRON DESIGNERS.

OCT. 26, 1900.

EXPERIENCE.

State what experience you have had to qualify you for the position of structural iron designer. Give dates, names of employers, and length of service.

1. Fig. 1 shows the stress sheet of a 130-ft. span; what will be the approximate weight of metal? Indicate method used for obtaining result.

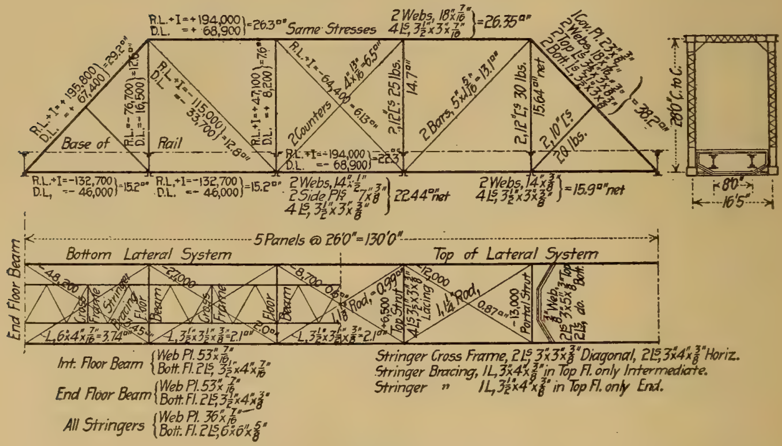


FIG. 1.

2. Calculate size of pin necessary for the connection shown in Fig. 2, assuming that 20 000 lb. per sq. in. are allowed in bending and 15 000 lb. per sq. in. in shear. Give details of calculation. Graphical method may be used.

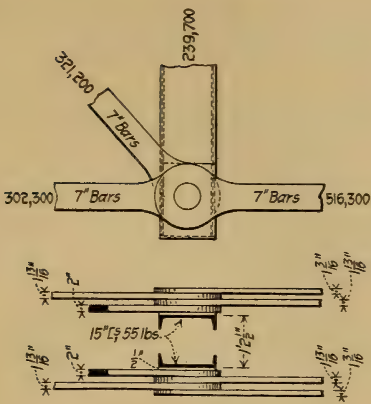


FIG. 2

3. A span of 80 ft. is required to carry street traffic. No limit is placed for the depth of the structure. Distance between centers of main girders is 24 ft. The pavement is to be cedar block laid on 4-in. planking, the latter resting directly on the steel floor. Assuming a moving load of 100 lb. per sq. ft., design the most economical floor, using steel floor beams and steel stringers and straining them not more than 12 000 lb. per sq. in. in the extreme fiber. Pencil sketches only will be required showing outline, sizes and dimensions. State weight of steel floor per linear foot of bridge. Give also the sectional material for the main girders.

4. An inclined end post, shown in Fig. 3, carries a total stress of 440 000 lb. The web is ⅝ in. thick, and there is only room for one ½-in. pin plate or hinge plate on the inside of each web. Assuming 18 000 lb. per sq. in. to be the permissible limit for bearing on pins, 7 500 lb. per sq. in. to be the limit for shear of rivets and 15 000 lb. per sq. in. to be the limit for bearing on rivets, calculate the size and number of pin plates, the number of ⅞-in. rivets required, and show their arrangement for a 6½-in. pin.

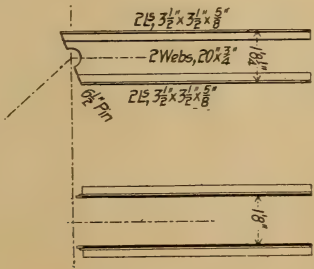


FIG. 3.

5. Do you consider a stiff or an adjustable lateral system as preferable for bridges? State your reasons.

6. A column fixed at the base is to carry a fixed load of 100 tons applied centrally and 10 tons applied eccentrically, 2 ft. from the center at top. Height of column, 40 ft. May be built of channels, Z-bars or plates and angles. Calculate column by any standard formula and give sketch of section with sizes and dimensions; also details of calculation and reasons for adopting the form of section.

7. What size and shape lattice bars would you use for a compression member built of 2 webs 30 by $\frac{3}{4}$ in. and 4 angles 6 by 6 by $\frac{3}{4}$ in., distance back to back of angles being 20 in.?

8. Describe, without going into details, how you would design the following structure: A 200-ft. highway span over railway track with viaduct approaches, as shown in Fig. 4. Bed rock, 6 ft. below surface of ground. The headroom over tracks to be 20 ft. under 200-ft. span. Top of floor to base of rail not to exceed 23 ft. No limitation as to headroom under approaches. Roadway to be 40 ft. wide in the clear between curbs, with two 6-ft. sidewalks. Indicate in writing the principal characteristics of each portion of the structure, such as length of spans, columns, girders, floor, bracing, etc., assuming that the highest class of structure is required.

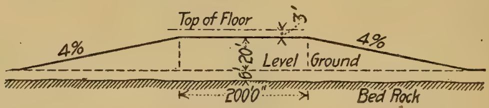


FIG. 4.

9. What is the relation between the deflection of a beam of equal resistance, or one which has a constant extreme fiber strain throughout its length, and the deflection of a beam of constant moment of inertia, all other conditions being equal?

10. Being given a continuous beam of 3 equidistant supports uniformly loaded, what is the end reaction expressed in terms of the total load?

The applicants may use a Carnegie "Pocket Companion" for reference in answering the above questions.

CIVIL SERVICE EXAMINATION FOR STRUCTURAL-IRON DESIGNERS AT CHICAGO.

JANUARY 1ST, 1903.

EXAMINATION QUESTIONS.

MATHEMATICS.

1. What would be the weight of a solid column 10 ft. long and 9 in. diameter if made of (*a*) cast iron; (*b*) wrought iron; (*c*) steel?

2. What should be the area in cross-section of a steel strut 1 ft. long that is to carry a load of 10 tons with a factor of safety of 4?

3. How many feet B. M. (*a*) in a floor 10 ft. wide by 120 ft. long made of 3-in. oak planks; (*b*) in an oak timber 6 by 14 in. and 18. ft. long?

4. What should be the diameter of a wrought-iron rod which is to stand a tensile strain of 7 000 lb. with a factor of safety of 7?

5. What is the moment of inertia of a box girder 7 in. square outside measurement and made of metal ½ in. thick?

DUTIES.

1. In braced portal, Fig. 1, find reactions and strains in rods.

2. In plate girder, Fig. 2, find spacing of rivets for a distance of 4 ft. from end "A"; also spacing of rivets between points X and Y. Allow 3 500 lb. bearing and 3 000 lb. for single shear per rivet.

3. In pony truss, Fig. 3, find maximum strain in members 1-3 and 1-4 for loads, as per diagram, moving over bridge.

4. In the same pony truss, what are the strains in members 3-4, 5-6, 3-6 and 5-4 for a panel dead load of 5 000 lb. when both diagonals are stiff members.

5. Find maximum bending moment on pins shown in Fig. 4.

6. In section shown in Fig. 5, find the radius of gyration around axis X-X; correct to two decimals.

7. Find section modulus "S" of section shown in Fig. 5.

8. In sidewalk bracket, Fig. 6, find the strain in member A-B.

9. Find the number of rivets required for member A-B in sidewalk bracket, Fig. 6. Member composed of two angles. Allow 3 500 lb. bearing and 3 000 lb. for single shear per rivet.

10. Find deflection at center of beam shown in Fig. 7.

NOTE.—Figure numbers refer to diagrams which were furnished to candidates.

JANUARY 21ST, 1904.

AN EXAMINATION OF CANDIDATES FOR CHIEF SANITARY INSPECTOR OF CHICAGO

was held in that city on January 13th. Some of the questions on general sanitation and hygiene were as follows:

Explain the germ theory of disease in its modern aspects.

What are the most prevalent diseases in cities and by what sanitary measures can they be most effectively combated?

What is the latest opinion concerning the dangers to health from leaky plumbing and broken drains?

What are the dangers of poisoning from small quantities of illuminating gas?

Why is it important to secure the drainage of wet places and the removal of stagnant water about dwellings?

What role do insects, such as flies and mosquitoes, play in the transmission of infection?

How does defective tenement-house construction facilitate the spread and maintenance of infection?

What is the scope of work of a sanitary bureau, and what is it intended to accomplish?

What measures, in your opinion, are most likely to aid in improving the sanitation of a large modern city?

What, precisely, do you understand by the term "cleanness," as applied, for example, to streets and alleys, to schoolhouses and other public buildings and to the ordinary dwelling-house?